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of Transportation

**Federal Highway
Administration**

Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: Program Maintenance Manual

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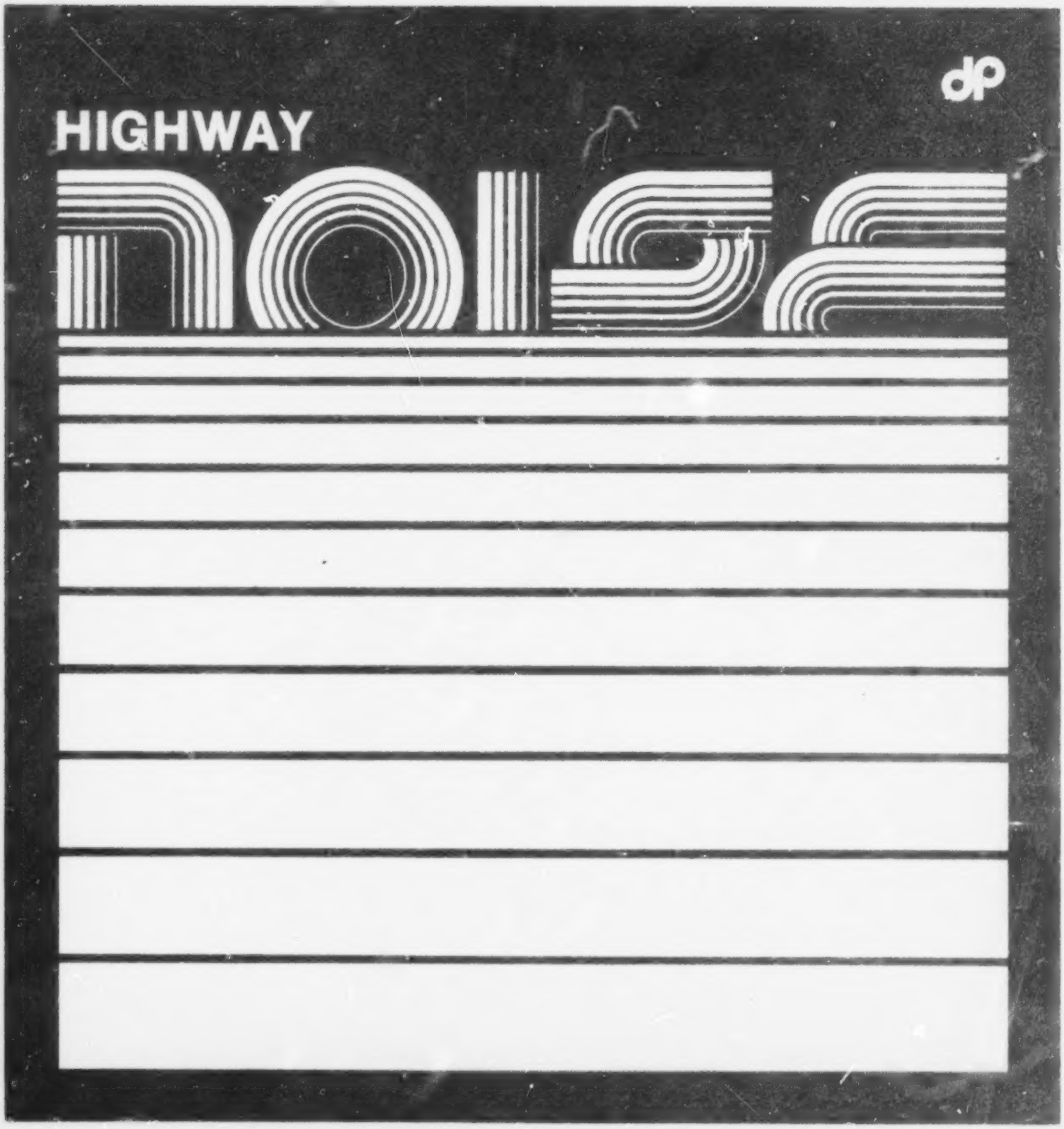
**FHWA-DP-58-2
Demonstration Projects Program
June 1982**



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16. Abstract

The Barrier Cost Reduction (BCR) Procedure is composed of two computer programs: STAMINA 2.0, the FHWA Highway Traffic Noise Prediction Model; and OPTIMA, an interactive program which helps the user design cost-efficient noise barrier designs. This manual describes the programs, and their subroutines in detail.

Complete documentation of the BCR Procedure consists of this report, a copy of the code listing and/or program tape, and the User's Manual (Report FHWA-DP-58-1).

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PROGRAM MAINTENANCE MANUAL

NOISE BARRIER COST REDUCTION PROCEDURE

STAMINA 2.0 AND OPTIMA

Edited By

Federal Highway Administration
Demonstration Projects Division
1000 North Glebe Road
Arlington, Virginia 22201

JUNE 1982

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1. ORGANIZATION

This document includes the Program Maintenance Manual, the Operations Manual, and the Installation Procedures for the BCR Procedure programs, STAMINA 2.0, and OPTIMA. The BCR User's Manual provides additional information on the operation of the programs. This section gives an overview of the organization of the document. To find specific items in the manuals, please refer to the Table of Contents.

The Program Maintenance Manual has four sections for each of the two programs. The first two sections (Secs. 2 and 3 for STAMINA, and Secs. 6 and 7 for OPTIMA) present discussions of the main and subprogram routines in detail. The last two sections (4 and 5 for STAMINA and 8 and 9 for OPTIMA) concern array sizes and common block allocations.

Section 10 presents a brief overview of the STAMINA 2.0 and OPTIMA programs. Section 11 contains the detailed procedures for installing these programs.

2. STAMINA 2.0: ARCHITECTURE OF PREDICTION CODE AND MAIN PROGRAM

2.1 INTRODUCTION

The STAMINA 2.0 highway traffic noise prediction program is basically the STAMINA 1.0 version released in May 1979; with the addition of barrier height increment geometry to define various barrier height possibilities used in the computation of the sound energy values for different barrier designs.

The program allows the user to make one computer run encompassing all possible barrier height changes designs a designer would need to compute. The program will output the sound energy values to a secondary storage device (named TAPE8) to be saved for later use in the barrier design program OPTIMA. The output contains all of the information on barriers and receivers necessary for computing the sound level at each receiver for various barrier height designs.

The STAMINA 2.0 program retains much of the original (STAMINA 1.0) structure, except for the GEOMRY subroutine (the most complex), which has been modified to reflect the barrier height changes The subroutines that have been added are: CONVER, FILEO, FILEC, BARPRP, CDELP, NBSET, OUTP1, OUTP2 and PH. Subroutine INPUT has been completely rewritten to allow free field (list-directed) input of all variables; making data input much easier.

STAMINA 2.0 is a batch operating program, since the data input and computation are quite large. But the program does contain two routines that could be used in a time-share environment: FILEO and FILEC.

FILEO is designed to allow the user to define a previously entered data file as input to the STAMINA 2.0 program at the time of execution. The default name is BCRINPT--which is equivalenced to a logical file unit (or, local file) TAPE5. The program would allow the user to specify the output data file to be saved and used, by the program OPTIMA, as TAPE8. The system output would be directed to file TAPE6, and the time-share output--to file TAPE7. The time-share input would be equivalenced to TAPE4.

Upon successful completion of STAMINA 2.0, subroutine FILEC would be used to close all files used during the program execution and to save permanently the output file TAPE8--for later use by program OPTIMA.

The MAIN program is described in detail in this section. Detailed descriptions of the subprograms are provided in Sec. 3. Following the description of each subprogram, the listing for that block of code is presented. The organization of the prediction code is illustrated in Figure 2-1.

2.2 MAIN PROGRAM DESCRIPTION

The MAIN program controls the flow of operations required to perform the highway traffic noise estimates at each receiver. The MAIN program calls various subprograms that conduct the bulk of the calculations. The basic program variables initialized by the MAIN program are NQ=3, NG=0, and NB=0 (i.e., three vehicle types, no absorptive ground strips, and no barriers).

The main program immediately reads and prints the user-defined title. Next, the MAIN program calls SUBROUTINE INPUT to read the input data defining the problem. If the user fails to properly define a roadway and/or a barrier by at least two end points, an error message is printed and the MAIN program attempts to read the next data set.

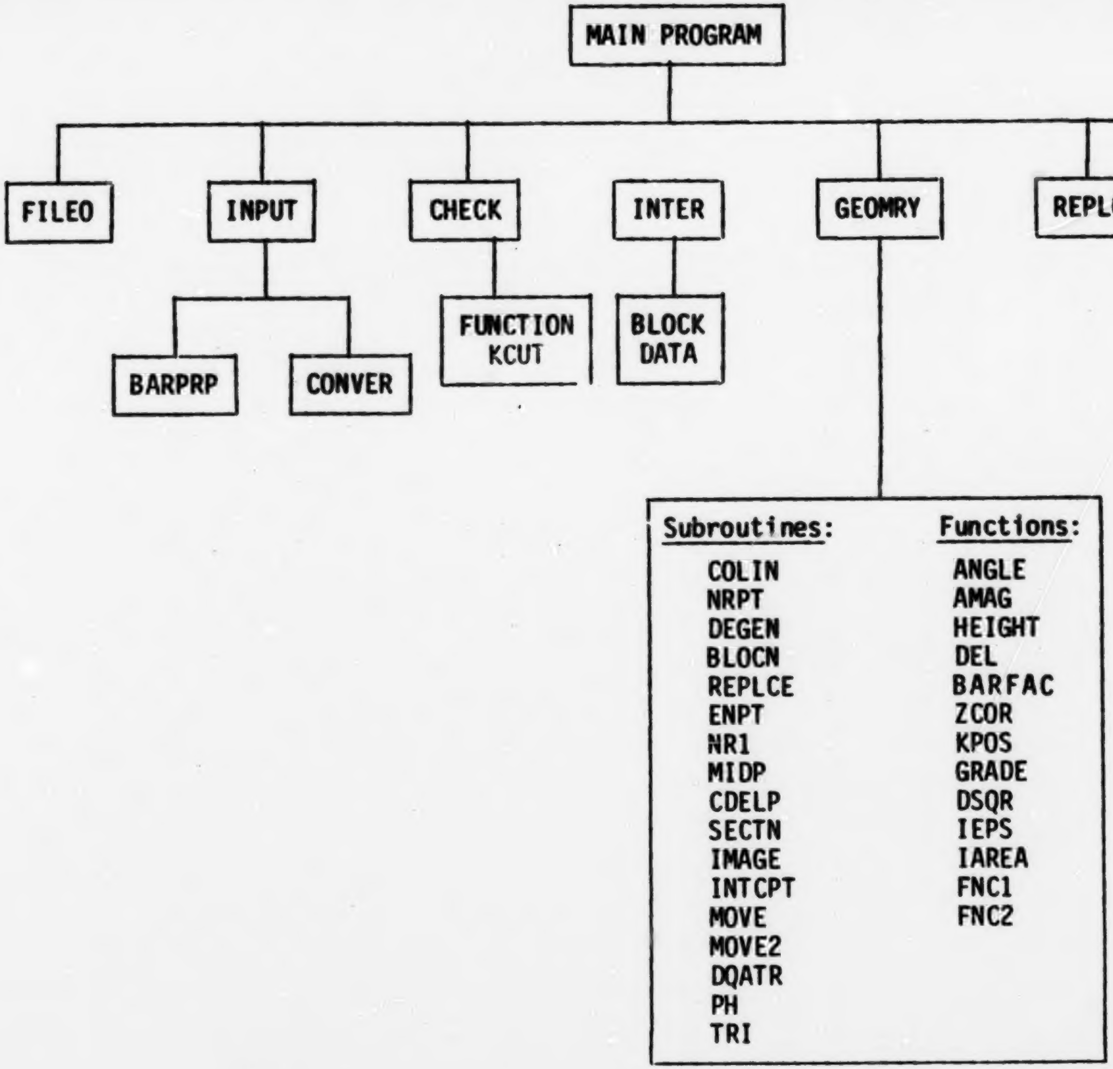

FIG. 2-1. ARCHITECTURE OF PREDICTION CODE: STAMINA 2.0.

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Following execution of INPUT, the MAIN program calls SUBROUTINE CHECK to determine if either a barrier segment or an absorptive ground strip center line intersect a roadway segment. If such an intersection occurs an error message is printed for each such intersection.
Following the execution of CHECK, the MAIN program is ready to begin sound level estimates if no errors have been encountered.

The MAIN program next calculates the reference distance sound levels and standard deviations for each vehicle type, traffic flow condition, and each frequency band specified for all roadways. This calculation is conducted by SUBROUTINE INTER. Following execution of subroutine INTER, the MAIN program begins the receiver sound level estimates in the following sequence:

The array, XLE(J), is initialized to zero. This array contains the normalized values of the acoustic intensity at the receiver for the overall A-weighted intensity, XLE(1).

The MAIN program next selects the roadway number and initializes the coordinates of the first end point of the roadway segment (array, XR1(J)). The next end point of the roadway segment is specified (array XR2(J)) and the basic problem is defined for the prediction code (i.e., roadway segment/receiver geometry .

To perform the calculations related to the basic problem defined for the code, the MAIN program calls subroutine GEOMRY. The vast bulk of the calculations performed by the prediction code are conducted in subroutine GEOMRY. If no errors are encountered in subroutine GEOMRY
the MAIN program continues the roadway analysis for each roadway segment until all roadways have been considered. The normalized acoustic intensity is accumulated in the array XLE(J) in subroutine GEOMRY.

Following the analysis of all roadways (sources) for the specified receiver, the MAIN program next calculates the standard deviation, SIGL, for the composite traffic noise and adjusts the normalized acoustic intensity, XLE(J), into absolute units of sound level (also stored in array XLE(J)). The main program then calculates the sound level descriptors LE(A) (XLD(1)), L50, L10, and L90. The output data is printed for the specified receiver and the MAIN program selects the next receiver continuing the above sequence until all receivers have been considered.

The flow diagram for the main program is illustrated in Figure 2-2. Statement numbers are presented at points on the flow diagram so that the user may refer to specific blocks of code as required.

2.3 MAIN PROGRAM VARIABLE LIST

The variables used in the MAIN program are listed below. Common and array variables are not indicated as such; however, the user may refer to Section 4, as required, to determine appropriate array sizes. Variables not listed are described in the subprograms where they are utilized.

ALEVEL (NRC)	A-weight sound intensities
ALP(NRC)	8 character alphanumeric descritive I.D. for receivers
CAP2	Cumulant for the A-weighted acoustic intensity
CON	Temporary scaling constant
GAM	Specific alpha factor input to GEOMRY
GAMA(NR,NRC)	Alpha factors matrix
I	Index for receiver loop
IB	Index
IH	Index
IOPT	Option symbol "*"
IQ	Index for vehicle type
IREFL	Flag indicating whether or not reflection calculations to be performed
IYES	Option symbol "Y"
J	Index for frequency band
JJ	Index
M	Index for roadway number

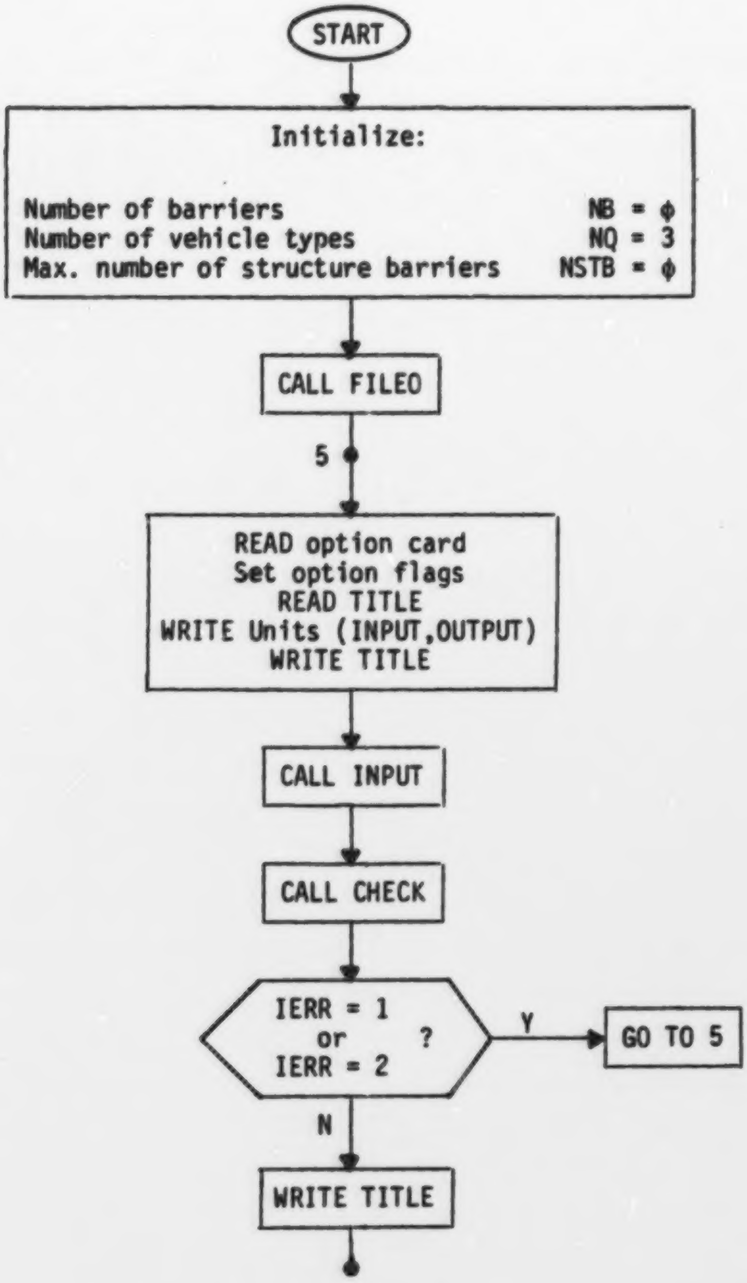

FIG. 2-2. MAIN PROGRAM FLOW DIAGRAM.

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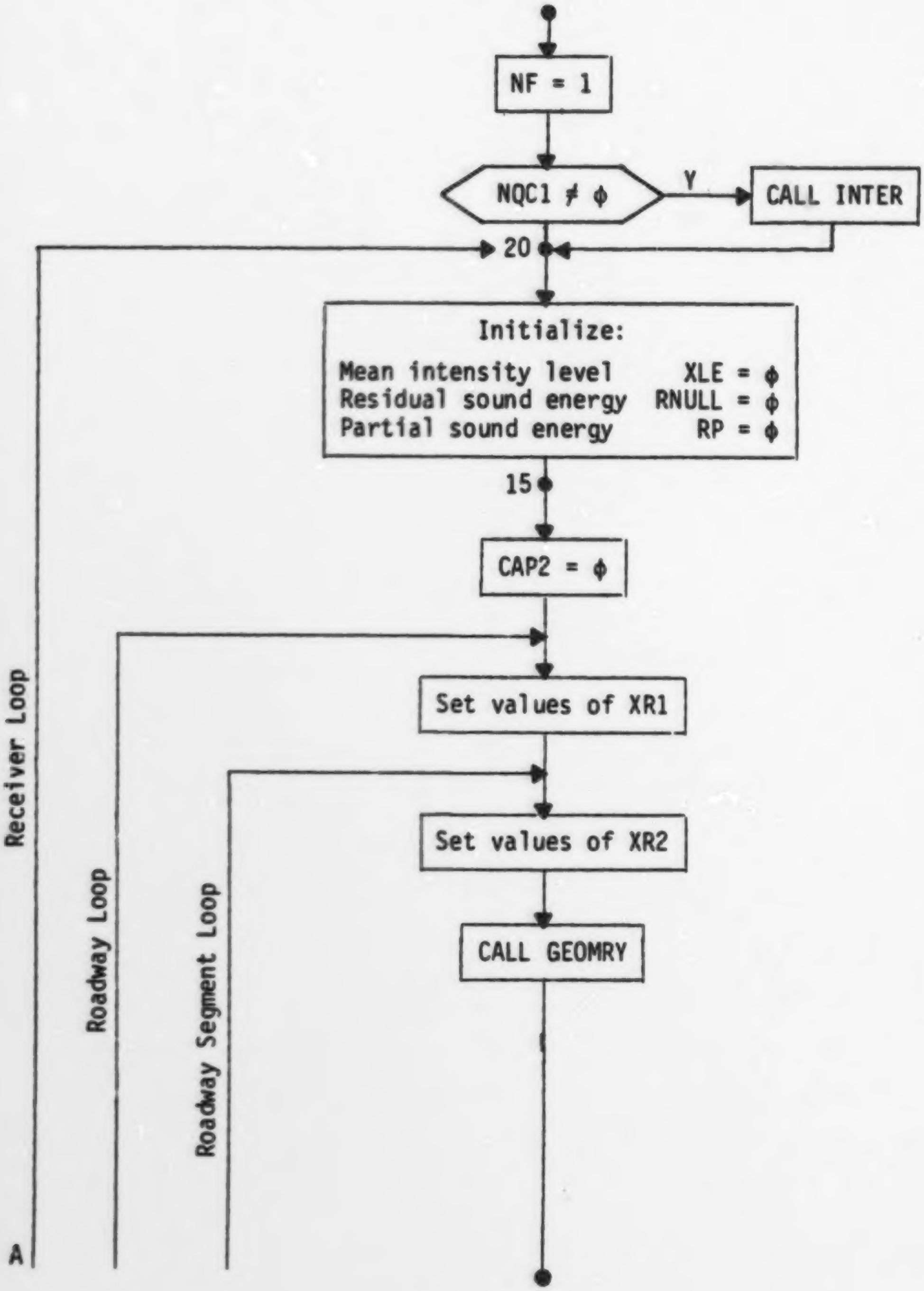

FIG. 2-2. (Continued)

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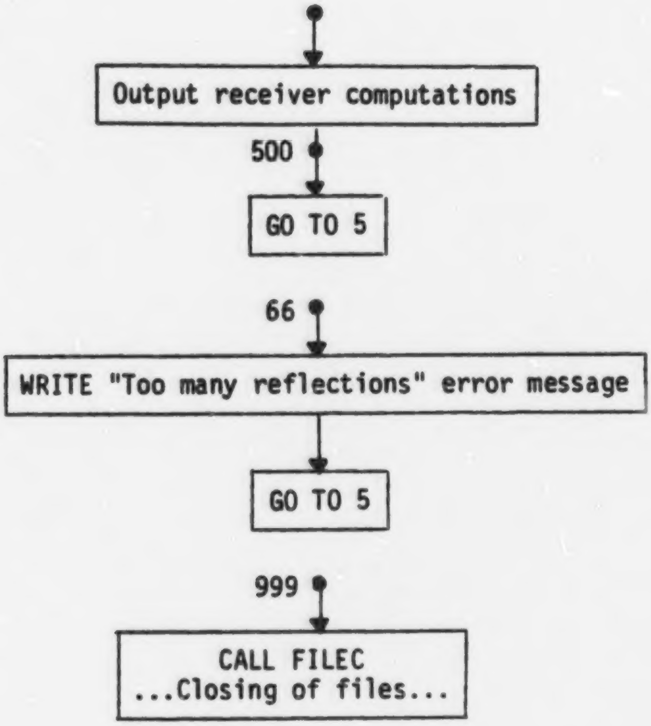
Output receiver computations
500
GO TO 5
66
WRITE "Too many reflections" error message
GO TO 5
999
CALL FILEC
...Closing of files...

FIG. 2-2. (Concluded)

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XL50	A-weighted sound exceeded 50% of the time
XL90	A-weighted sound exceeded 90% of the time
XR1	Road section initial point
XR2	Road section end point
XRC	x-coordinate of receiver
YRC	y-coordinate of receiver
ZRC	z-coordinate of receiver

SIZE: 4184

3. STAMINA 2.0: SUBPROGRAM DESCRIPTIONS

This section contains the description of the forty-three (43) subprograms utilized by the prediction code to estimate highway traffic sound level estimates. The code utilizes 28 Subroutine subprograms and 15 Function subprograms. Each subprogram is described as an independent block of text using a standardized format. The subprograms and functions appear in the order they appear in the program.

For each subprogram the following format is used to describe the subprogram:

PURPOSE: The purpose of the subprogram is described.

SUBPROGRAMS USED: The subprograms used by the subprogram are listed.

VARIABLES: The variables used by the subprogram are described in sequence: Input parameters, subprogram parameters, output parameters.

RESTRICTIONS: Any restrictions that should be recognized by the user are described.

ACCURACY: The accuracy of the subprogram is described (if appropriate).

SIZE: The compiled size of the subprogram is given in bytes.

REFERENCES: Any appropriate references are listed.

FIGURES: Any figures required to understand the subroutine are presented.

3.1 SUBROUTINE FILEO

PURPOSE: This subroutine is designed to allow the time-share user to define a previously entered data file as input to STAMINA 2.0 at the time of execution.

SUBPROGRAMS USED: None

STRUCTURE: The default name (of data file) is BCRINPT--which is equivalenced to a logical file unit (local file) TAPE5. The porgram allows the user to specify the output data file to be saved and used, by the program OPTIMA, as TAPE8. The system output is directed to file TAPE6, and the time-share output--to file TAPE7. The time-share input is equivalenced to TAPE4.

SIZE: 246

RESTRICTIONS: None

REFERENCES: None

SUBROUTINE FILEC

PURPOSE: This subroutine, like FILEO, is designed to enable the use of STAMINA 2.0 in a time-sharing environment. Upon successful completion of STAMINA 2.0, subroutine FILEC is used to close all files used during execution and to permanently save the output file TAPE8--for later use in program OPTIMA.

SUBPROGRAMS USED: None

SIZE: 246

RESTRICTIONS: None

REFERENCES: None

3.3 SUBROUTINE BLOCK DATA

PURPOSE: To provide a data block of coefficients for the interpolation polynomials used by subroutine INTER in calculating the vehicle noise emission characteristics.

SUBPROGRAMS USED: None

VARIABLES:

CO (NQ) - Constant terms in the vehicle sound level interpolation polynomial for the frequency bands NF and vehicle type NQ.

C1 (NQ) - Coefficients of the log term in the vehicle sound level interpolation polynomial

SO (NQ) - Constant terms in the vehicle sound level standard deviation interpolation polynomial for the frequency band NF and the vehicle type NQ.

INPT - Constant specifying the input device to be used by the prediction code (5 denotes a card reader)

IOUT - Constant specifying the input device to be used by the prediction code (6 denotes a line printer)

RESTRICTIONS: The constants CO(NQ), C1(NQ), SO(NQ) are stored as follows:

CO(1), CO(2) . . . CO(8); etc.

The user should note that all constants relating to the types 4 through 8 vehicles are set to zero unless they are defined by the user upon input.

SIZE: Not Applicable.

REFERENCES: See Section A.2 of Appendix A, Subroutine INTER and Subroutine INPUT.

3.4 SUBROUTINE INPUT

PURPOSE: Performs all input to the program, except for the option card and main title card--read by MAIN. All input data are stored in common blocks and listed.

SUBROUTINES USED: BARPRP, CONVER

VARIABLES: Input Parameters

METIN - Option flag indicating units of input.
METOUT - Option flag indicating units of output.

Subroutine Parameters

AA - Alpha-constant "A"; barrier type designation.
ATITLE - 80 character alphanumeric descriptive heading for alpha-factors data ... currently not output.
CO(IDN-2)
C1(IDN-2) - Sound level spectra--present for vehicle types 1, 2, 3; user-defined for types 4 and higher.
DECONI
DECONO - Conversion constants (5280 or 1000) defined according to METIN, METOUT.
I - Index.
IDN - Index for program initialization parameter.

IDUN - Input vehicle type

IGO - Index for data blocks.

SUBROUTINE INPUT (Continued)

SS	- Alpha-constant "S."
SO(IDN-2)	- Standard deviation of sound level spectra; same definition (w.r.t. vehicles) as CO, C1.
STITLE	- 80 character alphanumeric descriptive heading for shielding factors--currently not output.
VALUE	- Initialization parameter.
VEH	- Number of vehicles per hour input.
VEXPH(NR,NQC1,ITY)	- Vehicle concentration per roadway per vehicle group per vehicle type.
XMH	- Vehicle speed input (mph or kph).
ZRCHAJ	- Equivalenced to RDIN(1)--receiver height adjustment.

Output Parameters

ALP(NCR)	- 8 character alphanumeric receiver I.D.'s.
ALP1(6,NQ2)	- Alphanumeric (height adjustment) descriptive headings for output of initialization parameters.
BLAST(NB)	- Associated with type of last barrier section per barrier.
BT(NB,NSEC)	- 8 character alphanumeric barrier section.
BTITLE	- 80 character alphanumeric descriptive heading for barrier data.
BX(NB,NSEC) BY(NB,NSEC) BZ(NB,NSEC)	- Endpoint coordinates of barrier sections.
DZ(NB)	- Area height increment per barrier.
GAMA(NR,NRC)	- Alpha factors matrix.

SUBROUTINE INPUT (Continued)

IGOO(NR,NSEC)	- Grade designation, per roadway, per roadway section.
IST(NB,NO)	- Roadway numbers associated with structured barriers.
IVEH(8)	- Vehicle types.
NHP	- Number of height perturbations.
NP(NB)	- Number of ± perturbations per barrier.
RCTLE	- 80 character alphanumeric descriptive heading for receiver data.
RT(NR,NSEC)	- 8 character alphanumeric I.D. for roadway sections.
RTITLE	- 80 character alphanumeric descriptive heading for roadway data.
RX(NR,NSEC) RY(NR,NSEC)	- Coordinates for endpoints of roadway sections (feet or meters).
RZ(NR,NSEC)	
SBL(NBSEC)	- Barrier section length per barrier section.
TR(NR,NRC)	- Shielding factors matrix.
VTEMP	- Temporary vehicles per hour in output.
XMPH(NR,NQC1,NQ)	- Vehicular speed in output--per roadway per vehicle group per vehicle type.
XRC(NRC) YRC(NRC) ZRC(NRC)	- Receiver coordinates

SUBROUTINE INPUT (Continued)

ZO(NB,NSEC) - "Zero heights"--per barrier section.

NOTE: Variables IDUM(NG)IG,IT,BCS(NG),GTITLE,IDM,TGS(NG,1),TGS(NG,2), XXG1(NG,J),YYG1(NG,J),ZZG1(NG,J) refer to absorptive ground strips, which are not used in this version of STAMINA.

RESTRICTIONS:

Input vehicle speed should be within the range of 30-65 mph (or 50-105 kph). Speed less than 30 mph (50 kph) will be adjusted by the program to 30 mph (50 kph). Speed over 65 mph (105 kph) will be adjusted to 65 (105). Sound level spectra and standard deviation coefficients (C0, C1, S0) must be user-defined for any vehicle types above Type 3.

SIZE: 21246

REFERENCES: None

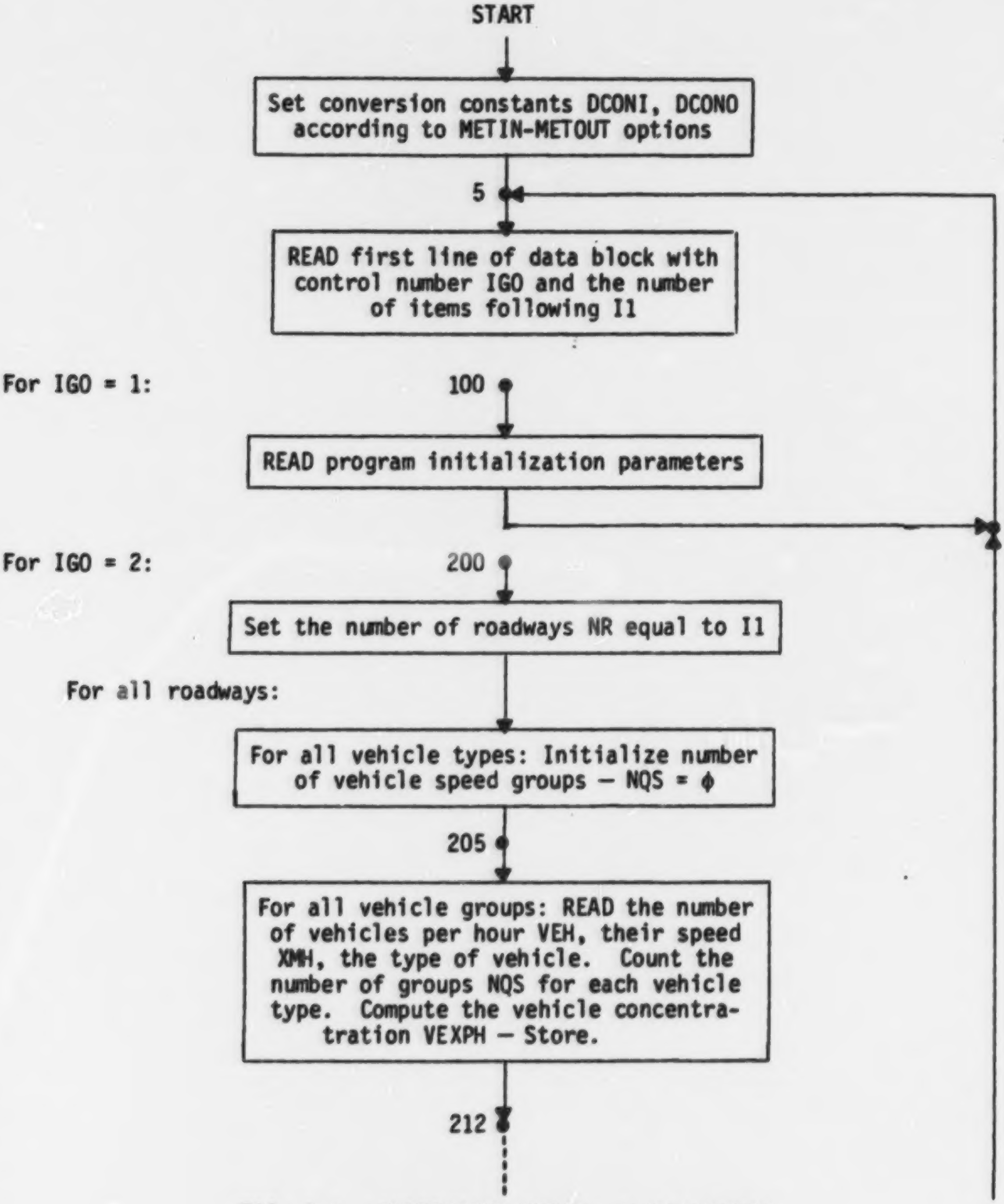
START
Set conversion constants DCONI, DCONO according to METIN-METOUT options
5
READ first line of data block with control number IGO and the number of items following I1
For IGO = 1:
100
READ program initialization parameters
For IGO = 2:
200
Set the number of roadways NR equal to I1
For all roadways:
For all vehicle types: Initialize number of vehicle speed groups — NQS = ϕ
205
For all vehicle groups: READ the number of vehicles per hour VEH, their speed XMH, the type of vehicle. Count the number of groups NQS for each vehicle type. Compute the vehicle concentration VEXPH — Store.
212

FIG. 3-1. SUBROUTINE INPUT: FLOW DIAGRAM

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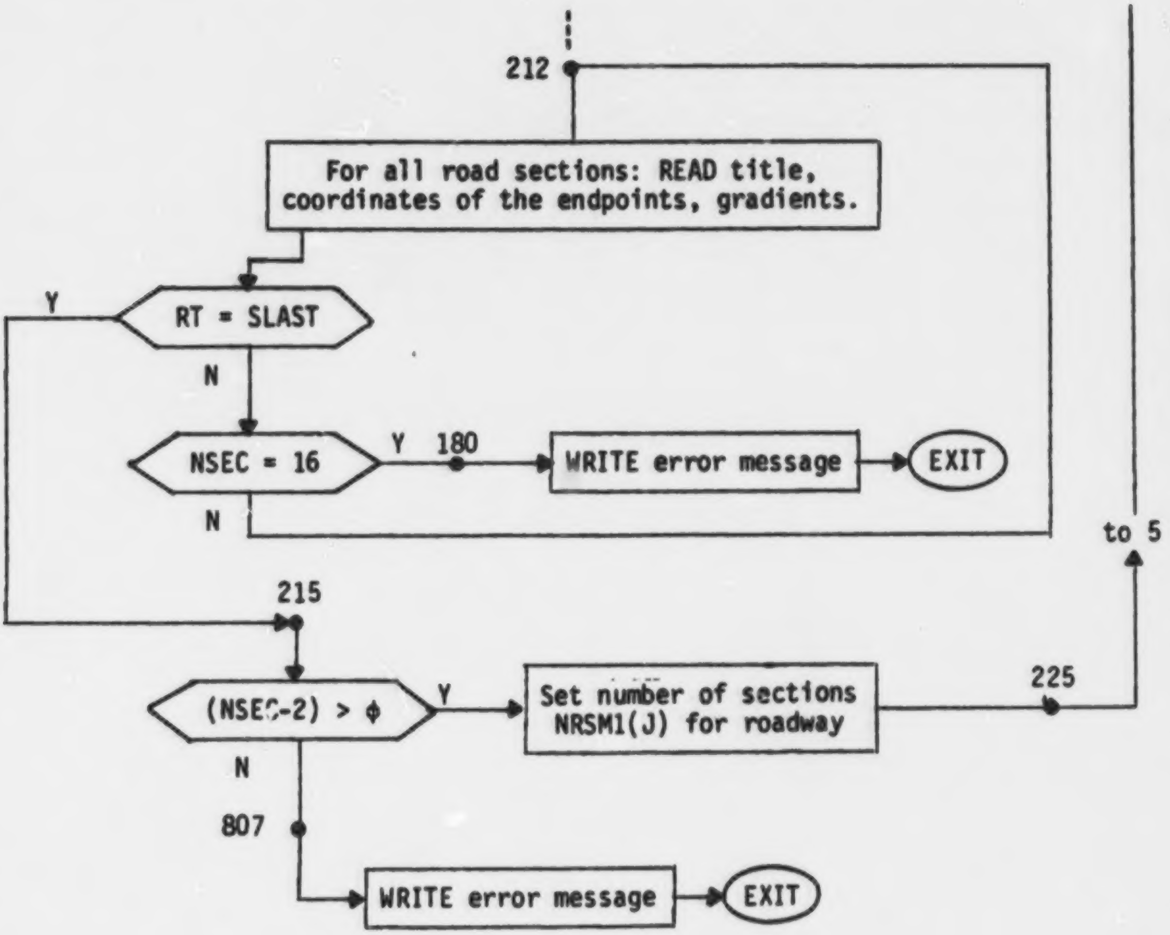
212
For all road sections: READ title, coordinates of the endpoints, gradients.
Y
RT = SLAST
N
NSEC = 16
Y
180
WRITE error message
EXIT
N
to 5
215
(NSEC-2) > ϕ
Y
Set number of sections NRSM1(J) for roadway
225
N
807
WRITE error message
EXIT

FIG. 3-1. (Continued)

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For IGO = 3:

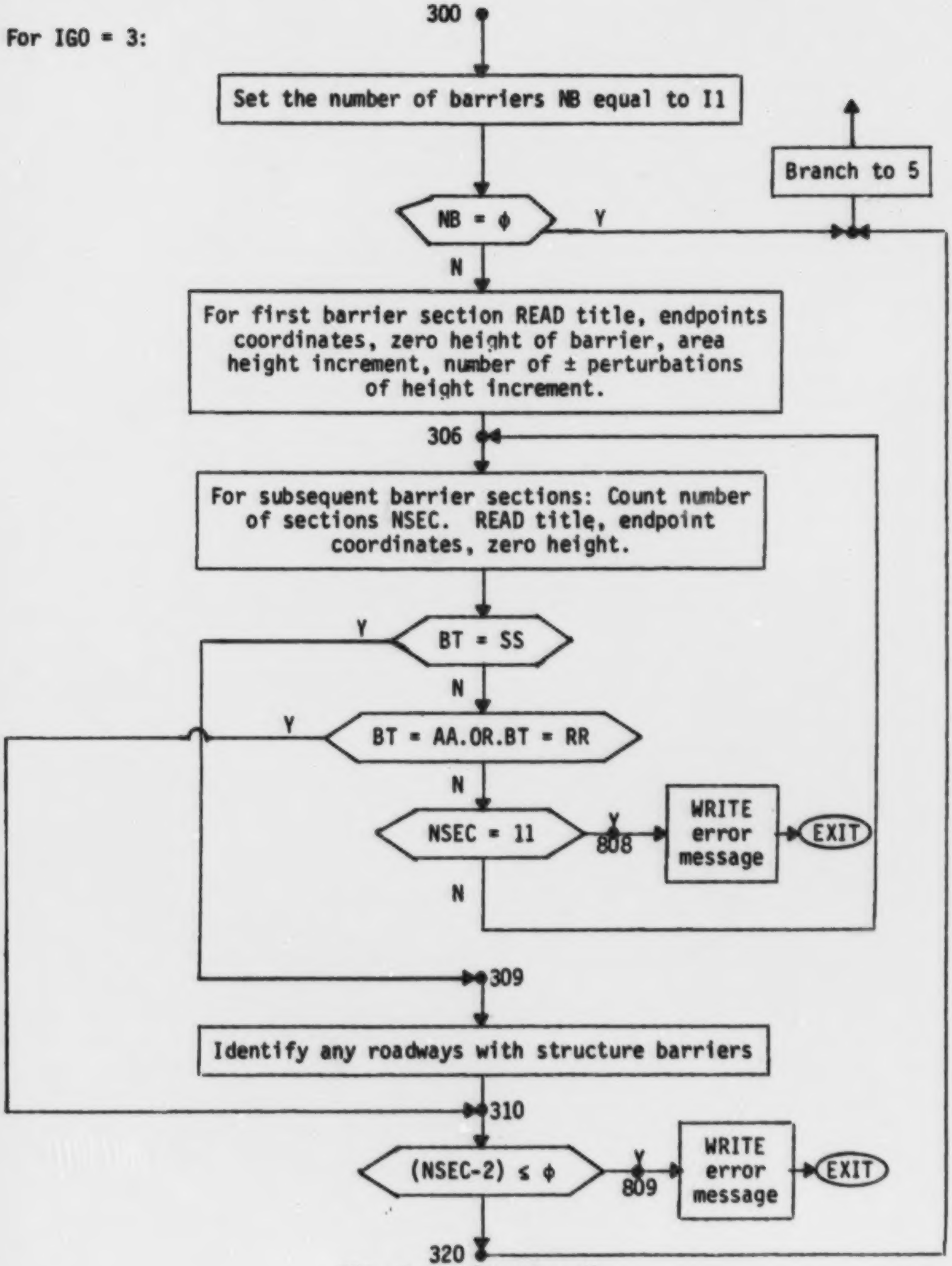
300
Set the number of barriers NB equal to I1
NB = ϕ
Y
Branch to 5
N
For first barrier section READ title, endpoints coordinates, zero height of barrier, area height increment, number of ± perturbations of height increment.
306
For subsequent barrier sections: Count number of sections NSEC. READ title, endpoint coordinates, zero height.
Y
BT = SS
N
Y
BT = AA.OR.BT = RR
N
NSEC = 11
Y
808
WRITE error message
EXIT
N
309
Identify any roadways with structure barriers
310
(NSEC-2) ≤ ϕ
Y
809
WRITE error message
EXIT
320

FIG. 3-1. (Continued)

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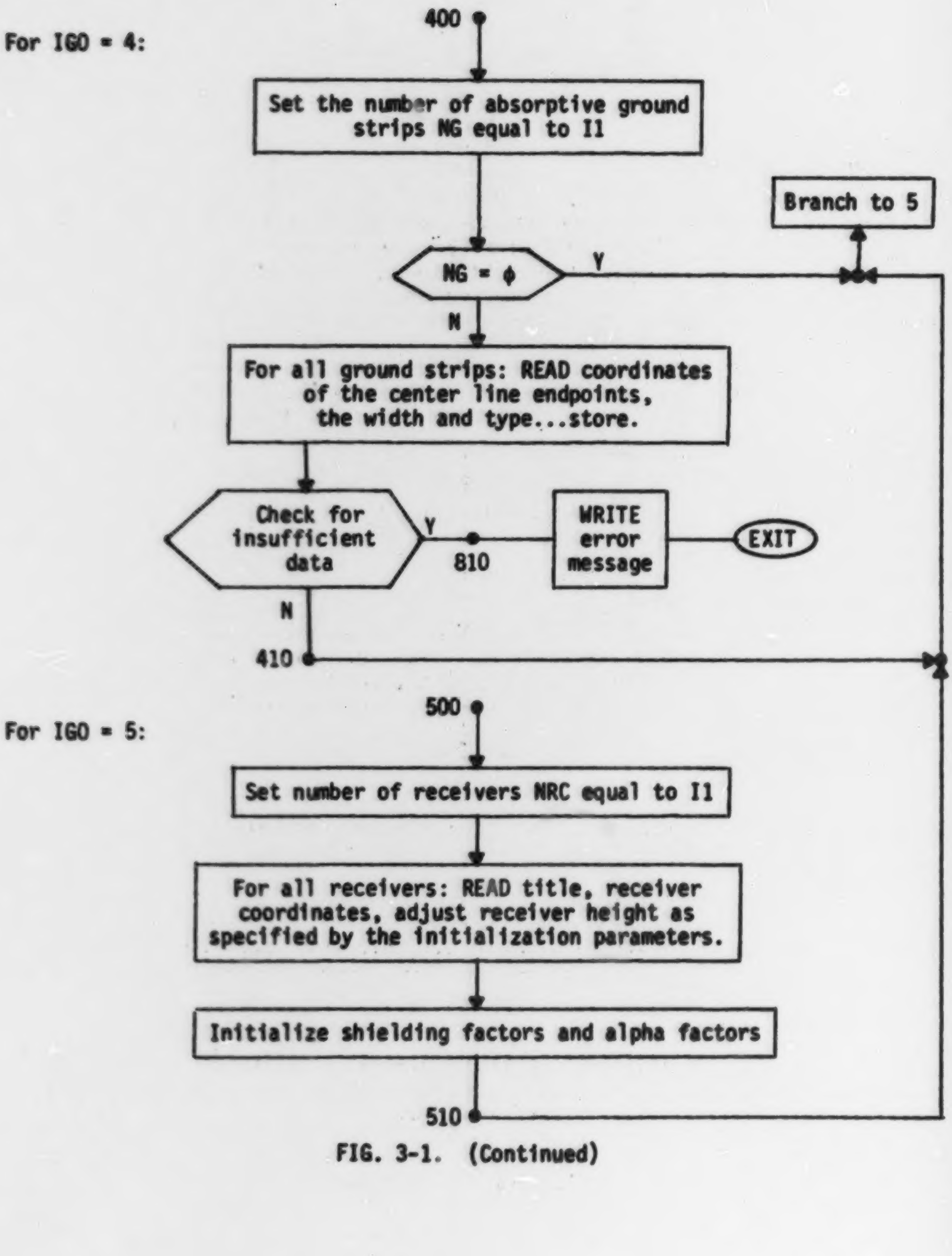
For IGO = 4:
400
Set the number of absorptive ground strips NG equal to I1
Branch to 5
NG = ϕ
Y
N
For all ground strips: READ coordinates of the center line endpoints, the width and type...store.
Check for insufficient data
Y
810
WRITE error message
EXIT
N
410
For IGO = 5:
500
Set number of receivers NRC equal to I1
For all receivers: READ title, receiver coordinates, adjust receiver height as specified by the initialization parameters.
Initialize shielding factors and alpha factors
510

FIG. 3-1. (Continued)

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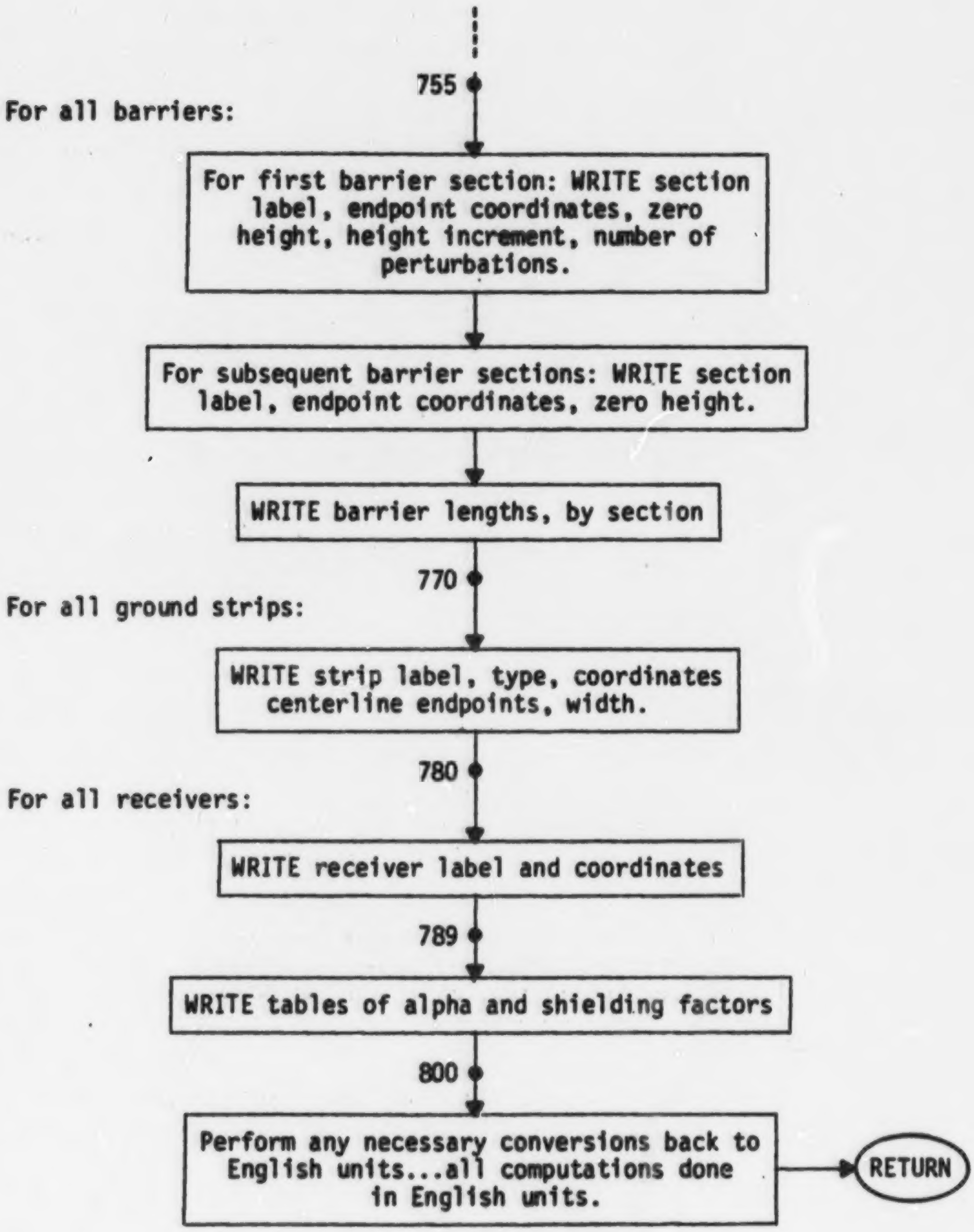
755
For all barriers:
For first barrier section: WRITE section label, endpoint coordinates, zero height, height increment, number of perturbations.
For subsequent barrier sections: WRITE section label, endpoint coordinates, zero height.
WRITE barrier lengths, by section
770
For all ground strips:
WRITE strip label, type, coordinates centerline endpoints, width.
780
For all receivers:
WRITE receiver label and coordinates
789
WRITE tables of alpha and shielding factors
800
Perform any necessary conversions back to English units...all computations done in English units.
RETURN

FIG. 3-1. (Concluded)

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3.5 SUBROUTINE CONVER

PURPOSE: Performs all length conversions from english to metric or from metric to english--as required by STAMINA 2.0.

SUBROUTINES USED: None

STRUCTURE: Conversion from english to metric, or the reverse, is determined by the entry point (CONVEM or CONME). Accordingly, two conversion constants (CONVS and CONVD) are set--relating miles to kilometers and feet to meters. A third and final constant (CONVL) is set, according to CONVS; needed in the conversion of sound level spectra.

The remainder of the subroutine consists of an orderly progression through all the pertinent program data--roadway, barrier, receiver--converting units as "requested."

VARIABLES:

BX(NB,NSEC) BY(NB,NSEC) BZ(NB,NSEC)	Endpoint coordinates for barrier sections.
CONVD	Conversion constant.
CONVL	Conversion constant.
CONVS	Conversion constant.
CO(NQ) C1(NQ)	Sound level spectra.
DZ(NB)	Area height increment per barrier.
I	Index.
J	Index.
K	Index.
NB	Number of barriers.
NBSM1(NB)	Number of sections per barrier.

NQ — Number of vehicle types.

NR — Number of roadways.

NRC — Number of receivers.

NRSM1(NR) — Number of sections per roadway.

NSEC — Roadway or barrier section number.

RX(NR,NSEC)

RY(NR,NSEC) — Endpoint coordinatesof roadway sections.

RZ(NR,NSEC)

VEXPH(NR,1,NQ) — Vehicle concentration.

XMPH(NR,1,NQ) — Vehicular speed.

XRC(NRC)

YRC(NRC) — Receiver coordinates.

ZRC(NRC)

ZO(NB,NSEC)- "Zero Heights."

NOTE: Variables NG,XXG1(NG,J),YYG1(NG,J),ZZG1(NG,J) refer to groundstrips which are not used in STAMINA 2.0.

RESTRICTIONS: None

ACCURACY: Conversion constants carried to seven significant places

SIZE: 1694

REFERENCES: None

3.6 SUBROUTINE CHECK (IERR)

PURPOSE: To check for intersection of roadways and barriers or ground strips. If intersection exists, the program would return with an error code and execution would be terminated.

SUBPROGRAMS USED:

KCUT (X1, X2, X3, X4)
REPLCE (X2, X1)

VARIABLES:

Input Parameters

NR - Number of roadways
NRSM1(NR) - Number of roadway segments in each roadway
RX(M,N), RY(M,N) } X,Y coordinates of roadway segments
NB - Number of barriers
NBSM1(NB) - Number of segments in each barrier
BX(IBAR,ISEG), BY(IBAR,ISEG) } X,Y Coordinates of barrier segments

Subroutine Parameters

XR1(I) - Point 1 of roadway segment
XR2(I) - Point 2 of roadway segment
XB1(I) - Point 1 of barrier segment
XB2(I) - Point 2 of barrier segment

Output Parameters

IERR - Error code
IERR = 1, if barrier intersects roadway

NOTE: Variables NG,XXG1(IGRA,I),XXG2(IGRA,I),XG1,XGZ refer to ground strips which are not used in this version of STAMINA.

RESTRICTION: None

SIZE: 1492

REFERENCES: None

3.7 SUBROUTINE INTER (NR,IQ)

PURPOSE: To determine, by interpolation, vehicle emission and corresponding standard deviation, given a certain roadway, vehicle type and speed.

SUBPROGRAMS USED: BLOCK DATA (Transferred through COMMON/CONSTS/)

VARIABLES: Input Parameters

NR - Roadway number

IQ - Vehicle type number

C0(NQ)
C1(NQ) } Constants obtained by non-linear regression, using the following equation:

$$L(V) = C0(IF,IQ) + C1(IF,IQ) * \log (V)$$

where

V = speed at 25, 35, 45, 55 & 65 mph

L(V) = sound level at V

S0(NQ) Standard deviations obtained by similar method as above.

NQS(NR,IQ) - Number of traffic flow conditions

XMPH - Speed at which interpolation is done

Subroutine Parameters

V - Same as XMPH(NR,IQ)

INDEX - Position in arrays where the calculated emission level and the corresponding standard deviation are stored

MULT - Factor to be multiplied to obtain INDEX

SUBROUTINE INTER (NR, IQ) (Continued)

Output Parameters

XLREF(INDEX)- Value of reference acoustic intensity

CQ(INDEX) - Value of reference standard deviation factor

RESTRICTION: The constants for vehicle types 1 - 3 and their standard deviations are provided in the program. If a new type of vehicle is introduced, its corresponding constants and standard deviations must be read in from cards. See Subroutine INPUT.

REFERENCES: Ma, Y. Y., and Rudder, F. F., Jr.: "Statistical Analysis of FHWA Traffic Noise Data," U.S. Department of Transportation, Federal Highway Administration, Office of Research, Report No. FHWA-RD-78-64, July 1978.

SIZE: 812

3.8 FUNCTION AMAG (X1V,X2V)

PURPOSE:	To compute the length, AMAG, of a line segment defined by the end points X1V(I) and X2V(I), for an (x, y, z) coordinate system.
SUBPROGRAMS USED:	DSQR (X1V, X2V)
VARIABLES:	Input Parameters X1V(I), X2V(I) - Points defined by their x(I=1), y(I=2), z(I=3) coordinates.
RESTRICTIONS:	None.
ACCURACY:	Not Applicable.
SIZE:	370
REFERENCES:	Calculates the length of a line vector, $\vec{R}_{12}$, as AMAG = $(\vec{R}_{12} \cdot \vec{R}_{12})^{\frac{1}{2}}$.

3.9 FUNCTION ANGLE (X1V,X2V,X3V)

PURPOSE: To compute the angle between the two line segments defined by the points (X1V, X3V) and (X2V, X3V) for an (x, y, z) coordinate system.

SUBPROGRAMS USED: DSQR (X1, X2)

VARIABLES: Input Parameters

X1V(I), X2V(I), X3V(I) - Points defined by their x(I=1), y(I=2), z(I=3) coordinates.

Subprogram Parameters

D13 - Square of the length of the line segment defined by the points X1V(I) and X3V(I).

D12 - Square of the length of the line segment defined by the points X1V(I) and X2V(I).

D23 - Square of the length of the line segment defined by the points X2V(I) and X3V(I).

RESTRICTIONS: If point X3V coincides with either X1V or X2V, ANGLE = $\pi/2$.

ACCURACY: That of subprograms.

SIZE: 624

REFERENCES: COS (ANGLE) is calculated using the "Law of Cosines." ANGLE is calculated as COS^{-1} (COS(ANGLE)).

3.10 FUNCTION BARFAC (KF,DELP)

PURPOSE: To compute the attenuation of acoustic intensity for a propagation path over a barrier between a source point and a receiver point for a given path length difference, DELP, and octave band center frequency, denoted by the index KF.

SUBPROGRAMS USED: None.

VARIABLES: Input parameters

KF - Integer index, n, for octave band center frequency (see derivation below) or A-weighted sound level, (KF = 1).

Subprogram parameters

DELP - Path length difference, δ, between the diffracted ray and the direct ray between source and receiver.

IP - Variable internal to subprogram equal to KF.

A - $2\pi N$, where N is the Fresnel Number (see derivation below).

RESTRICTION: Theory based upon Fresnel diffraction using an analytical approximation to the experimental measurements of Maekawa. (See Section \A.6, Appendix A).

If KF=1, the A-weighted sound level is being utilized. This subprogram evaluates A-weighted sound level attenuation by calculating the attenuation at the octave-band center frequency of 500 Hz. (IP=5).

Speed of sound, c, is assumed to be 1120 ft/sec.

ACCURACY: That of subprograms.

SIZE: 988

FUNCTION BARFAC (KF, DELP) Continued.

REFERENCES: Maekawa, Z.: "Noise Reduction by Screens; Applied Acoustics, Vol. 1, 1968, pp 157-173.

Kurze, U.J., and Anderson, G.S.; "Sound Attenuation by Barriers", Applied Acoustics, Vol. 4, 1971, pp 35-53.

Kurze, U.J.; "Noise Reduction by Barriers", J. Acoustical Society of America, Vol. 55, No. 3, March 1974, pp 504-518.

DERIVATION: Development of the relationship for calculating the barrier factor (attenuation) as a function of Fresnel Number is presented in Section

For an octave band center frequency, f_c; a path length difference, δ; and a speed of sound, c; the Fresnel Number is defined as

$$N = 2f_c\,\delta/c$$

for $f_c = 2^n \cdot 10^3/64$; $n = 2,3,....9$, $c = 1120$ ft/sec.

$$N = 2f_c\,\delta/1120 = f_c\,\delta/560$$

$$N = 2^n \cdot 10^3\,\delta/(64 \cdot 560) = 2^n\,\delta/(35.84)$$

$$A = 2\pi N = 2^n\,\delta/(35.84/2\pi) = 2^n\,\delta/5.7$$

$$\text{BARFAC} = 10^{-D_b/10}$$

for $N \leq -0.2$; $A \leq -1.257$; $D_b = 0$; BARFAC$=1.0$

for $-0.2 \leq N \leq 0$ $-1.257 \leq A \leq 0$

$$D_b = 20 \cdot \log\ (\sqrt{|A|}/\text{TAN}(\sqrt{|A|})) + 5 = 20 \log\ (R) + 5$$

$$\text{BARFAC} = 10^{-(20 \log (R) + 5)/10} = (10^{0.5}R^2)^{-1}$$

$$\text{BARFAC} = (3.1623\ R^2)^{-1} = (\text{TAN}(\sqrt{|A|})/\sqrt{|A|})^2/3.16$$

for $N=0$; $A=0$; $D_b=5$; BARFAC $= 10^{-5/10} = 0.31623$

for $0 \leq N \leq 5.03$; $0 \leq A \leq 31.6$;

$$D_b = 20 \cdot \log\ (\sqrt{A}/\text{TAN H}(\sqrt{A})) + 5 = 20 \log\ (R) + 5$$

FUNCTION BARFAC (KF, DELP) Concluded

$$\text{BARFAC} = 10^{-(20 \cdot \log (R) + 5)/10}$$

$$= (3.1623\ R^2)^{-1} = (\text{TANH}(\sqrt{A}))^2/3.16A$$

for $N > 5.03$; $A > 31.6$ $D_b = 20$*

$$\text{BARFAC} = 10^{-20/10} = 10^{-2} = 0.0100$$

* Note:Previous versions of this subroutine placed an upper limit of $D_b = 24$ dB on barrier attenuation (ie, BARFAC = $4 \cdot 10^{-3}$). The upper limit has been reduced to 20 dB based upon field experience.

3.11 SUBROUTINE BLOCN (X1V, X2V, X3V, X4V, X5V, X6V, LOC)

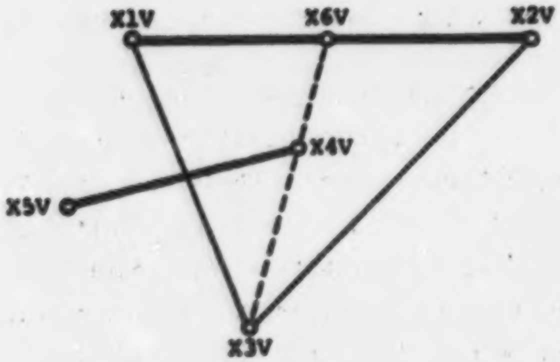
PURPOSE: This subroutine calculates the alignments in the x-y plane, of one line segment relative to the alignment of another line segment and a point. Physically, the line segment defined by the x(I = 1), y(I = 2) coordinates of the points X1V(I) and X2V(I) represents a road segment, the point X3V(I) represents a receiver, and the line segment defined by the points X4V(I) and X5V(I) represent a barrier.

The subroutine output is a point X6V(I) in the x-y plane and a configuration index, LOC. See Figure F-2.
If LOC = 0, the line segment defined by X4V, X5V is outside the triangle formed by X1V, X2V, X3V. In this case, the subroutine assigns no values to X6V.

If LOC = 1, this line segment defined by X4V, X5V intersects the line segment defined by X1V, X3V. In this case, the subroutine assigns X6V as the intersection point (in the x-y plane) of the line segment X1V, X2V and the line defined by the points X3V, X4V or X3V, X5V.

If LOC =2, the line segment defined by X4V, X5V intersects the line segment defined by X2V, X3V. In this case, the subroutine assigns X6V as the intersection point (in the x-y plane) of the line segment X1V, X2V and the line defined by the points X3V, X4V or X3V, X5V.

If LOC = 3, the line segment defined by X4V, X5V intersects both line segments defined by X1V, X3V and X2V, X3V (ie, the road segment, as viewed from point X3V, is completely covered by the line segment X4V, X5V). In this case, the subroutine assigns no values to X6V.



LOC = 0 denotes that the line X4V, X5V is outside the triangle X1V, X2V, X3V.

LOC = 1 denotes that the line X4V, X5V intersects the line X1V, X3V.

LOC = 2 denotes that the line X4V, X5V intersects the line X2V, X3V.

LOC = 3 denotes that the line X4V, X5V intersects both lines X1V, X3V and X2V, X3V.

LOC = 4 denotes that the line X4V, X5V is completely inside the triangle X1V, X2V, X3V.

FIGURE 3-2. SUBROUTINE BLOCN: RELATIVE GEOMETRY

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SUBROUTINE BLOCN (X1V, X2V, X3V, X4V, X5V, X6V, LOC) Continued

If LOC = 4, the line segment defined by X4V, X5V is interior to the triangle defined by the points X1V, X2V, X3V. In this case, the subroutine assigns X6V as the intersection point on the line segment X1V, X2V of the line from X3V to either X4V or X5V that is closest to the point X1V. SEE RESTRICTIONS

SUBPROGRAMS USED: KCUT(X1, X2, X3, X4), TRI(X1, X2, X3, X4, X5, KTRI), KPOS(X1V,XAV,XBV). INTCPT(X1, X2, X3, X4, X5), SEE RESTRICTIONS, SEE SUBROUTINE DEGEN.

VARIABLES: Input parameters

X1V(I), X2V(I) - points defining a road segment locatio. in the x(I=1), y(I=2) plane.

X3V(I) - a point defining the receiver location in the x(I = 1), y(I = 2) plane.

X4V(I), X5V(I) - points defining a line segment location in the x(I = 1), y(I = 2) plane.

Output parameters

X6V(I) - a point on the line segment defined by X1V(I), X2V(I) that represents the intersection of the line defined by either the points X3V, X4V or X3V, X5V. (SEE PURPOSE)

LOC - a parameter describing the configuration (SEE PURPOSE).

Subprogram parameters

KTRI - A parameter assigned by subprogram TRI.

KTRI = 0 if X4V is either exterior to the triangle X1V, X2V, X3V or lies on a line segment X1V, X2V; X1V, X3V; or X2V, X3V.

KTRI = 1 if X4V is interior to the triangle X1V, X2V, X3V.

SUBROUTINE BLOCN (X1V, X2V, X3V, X4V, X5V, X6V, LOC) Concluded

XAV(I)	- a point on the line segment defined by X1V(I), X2V(I) that represents the intersection of the line defined by X3V, X4V.
XBV(I)	- a point on the line segment defined by X1V(I), X2V(I) that represents the intersection of the line defined by X3V, X5V.

RESTRICTIONS: The subprogram BLOCN is used by the subprograms ENDPT and GEOMRY to establish the basic geometric relationship between a roadway segment (X1V, X2V); a receiver location, X3V; and a potentially intervening barrier segment (X4V,X5V). Geometric configuations between the five points defined by X1V, X2V, X3V, X4V, and X5V can arise that may either produce erroneous results or program failure. To check for these potential problems and to avoid the possibility of calculating erroneous results, the subprogram DEGEN is used. The problem geometrical configurations are associated with colinearity of source-receiver points X1, X2, X3 with barrier points X4V, X5V, or if the points X4V and/or X5V lie on the boundary of the triangle formed by the points X1V, X2V, X3V. See Figure E-2.

ACCURACY: SEE RESTRICTIONS.

SIZE: 958

REFERENCES: None.

3.12 FUNCTION DEL (X1V, X2V, X3V, X4V, HDIFF, DN1)

PURPOSE: To calculate the path length difference, DEL, between the ray from the source point, X1V(I), diffracted over a barrier defined by a line segment defined by the points (X3V(I), X4V(I)) towards a receiver location at the point X2V(I). Points and line segments are defined in an x(I = 1), y(I =2), z(I = 3) coordinate system.

SUBPROGRAMS USED: NRPT (X1, X2, X3, X4, DIST), DSQR (X1, X3)

VARIABLES: Input parameters

X1V(I) - Source point at x(I = 1), y(I = 2), z(I = 3)

X2V(I) - Receiver point at x(I = 1), y(I = 2), z(I = 3)

X3V(I) - End point of line segment at x(I = 1), y(I = 2), z(I = 3) defining barrier.

X4V(I) - End point of line segment at x(I = 1), y(I = 2), z(I = 3) defining barrier.

HDIFF - Height difference between source-receiver ray and top of barrier. (See function HEIGHT).

DN1 - Distance between source-receiver.

Subprogram parameters

DISTA - Distance from source to point XA(I).

DISTB - Distance from receiver to point XB(I).

DISTC - Square of distance between points XA(I) and XB(I).

XA(I) - Point on line defined by the line segment (X3V, X4V) that is nearest to the source point X1V(I).

XB(I) - Point on line defined by the line segment (X3V, X4V) that is nearest to the receiver point X2V(I).

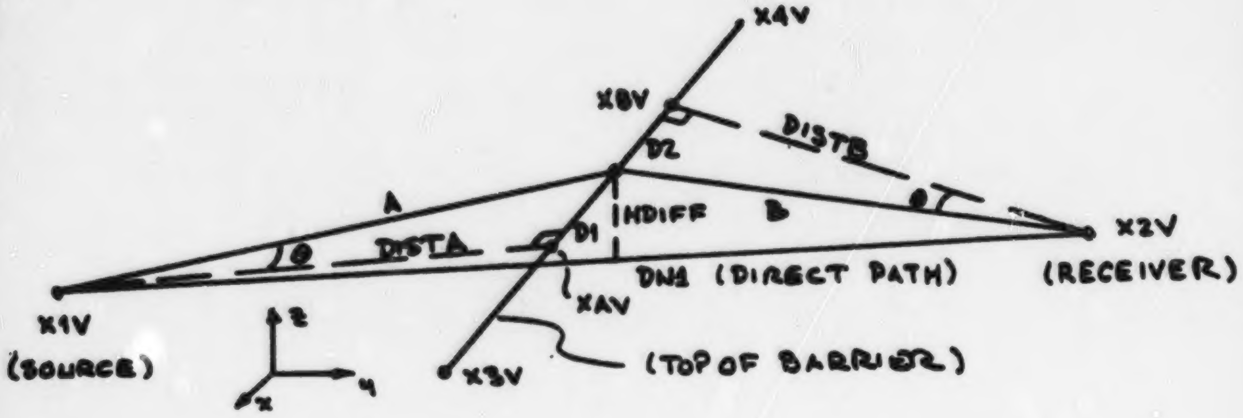
Output parameters

DEL - Path length difference. Positive if HDIFF is less than zero. Negative if HDIFF is greater than zero.

FUNCTION DEL (X1V, X2V, X3V, X4V, HDIFF, DN1) Concluded

RESTRICTIONS;	The subprogram does not check to see if the direct path from the source to the receiver intersects the barrier. Hence, it is possible to define input to the subroutine that yields a positive value of DEL when in fact DEL should be zero. Usage of this subroutine should recognize this restriction.
ACCURACY:	That of subprograms.
SIZE:	672
REFERENCES:	See Figure E-5 for derivation of algorithm.

FUNCTION DEL (X1V,X2V,X3V,X4V,HDIFF,DN1)



Basic Relationship: $DEL = A + B - DN1$

Basic Geometry:

$DISTA = A \cos\theta$ $\quad$ $D1 = A \, SIN \, \theta$

$DISTB = B \cos\theta$ $\quad$ $D2 = B \, SIN \, \theta$

$A^2 = DISTA^2 + D1^2$ $\quad$ $B^2 = DISTB^2 + D2^2$

$$DISTA \bullet DISTB + D1 \bullet D2 = AB \cos^2\theta + AB \, SIN^2\theta = AB$$

$$(A + B)^2 = A^2 + B^2 + 2AB$$
$$(A + B)^2 = DISTA^2 + D1^2 + DISTB^2 + D2^2 + 2\,(DISTA \bullet DISTB + D1 \bullet D2)$$
$$(A + B)^2 = (DISTA + DISTB)^2 + (D1 + D2)^2$$
$$DISTC \quad = (D1 + D2)^2$$

$$\therefore A + B - DN1 = SQRT((DISTA + DISTB)^2 + DISTC) - DN1$$

FIGURE 3-3 FUNCTION DEL: DERIVATION

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3.13 FUNCTION DSQR (X1V,X2V)

PURPOSE: To calculate the square of the distance between two points X1V(I), X2V(I) in x(I = 1), y(I = 2), z(I = 3) space.

SUBPROGRAMS USED: None.

VARIABLES: Input parameters

X1V(I), X2V(I) - Points defining a line segment by their x, y, z coordinates.

Output parameters

DSQR - The square of the distance between the points X1V(I), X2V(I).

RESTRICTIONS: None.

ACCURACY: Not applicable.

SIZE: 410

REFERENCES: DSQR is the scalar ("dot") product of the vector between points X1V and X2V.

$$\mathrm{DSQR} = \vec{R}_{12} \cdot \vec{R}_{12} = \vec{R}_{21} \cdot \vec{R}_{21}$$

3.14 SUBROUTINE ENDPT (X1V, X2V, X3V, X4V, X5V, X6V, KTRIG, IERR)

PURPOSE: To calculate the (x, y, z) coordinates of points on a roadway segment for which sound propagation may or may not be affected at a receiver location by an intervening barrier. (See RESTRICTIONS).

The input values of the points X1V, X2V define the initial roadway segment. The point X3V defines the observer location and the points X4V, X5V define the location of a barrier.

The subroutine calculates the index KTRIG and,as necessary, the point X6V on the line segment defined by the input values of X1V, X2V so that if KTRIG = 0, the line segment defined by the output values of X1V, X2V represent a road segment with a clear line of sight to the receiver X3V. If KTRIG = 0, the output values of X6V have no physical significance. If KTRIG = 1, the line segment defined by the output values of X1V, X6V represent a road segment with an obstructed (in the x-y plane) line-of-sight to the receiver at X3V and the line segment defined by the output values of X6V, X2V represent a roadway segment with a clear line-of-sight to the receiver at X3V.

The subroutine does not alter the input values of X1V, X3V, X4V, and X5V, but it may alter the input value of X2V. Also, the points X2V and X6V may coincide. (see VARIABLES and RESTRICTIONS).

SUBPROGRAMS USED: REPLCE (X1V, X2V), ZCOR (X1V, X2V, X3V), BLOCN (X1V, X2V, X3V, X4V, X5V, X6V, LOC), MOVE (X1V, X2V, X3V, DELTA, IERR) AMAG(X1V,X6V).

SUBROUTINE ENDPT (X1V, X2V, X3V, X4V, X5V, X6V, DTRIG, IERR) Continued

VARIABLES: Input parameters

X1V(I), X2V(I) - Points in x, y, z coordinate space defining the alignment of the roadway segment.

X3V(I) - A point in x, y, z coordinate space defining the receiver location.

X4V(I), X5V(I) - Points in x, y, z coordinate space defining a barrier.

Subprogram parameters

ITRIG - An index, internal to the subprogram, that indicates whether or not the input value of the point X1V and the point X6V initially calculated on the line segment (X1V, X2V) are so close that the significance of the segment (X1V, X6V) can be ignored in judging the effect of the barrier (X4V, X5V). The subroutine considers "close" to be a distance of 0.51 feet.

LOC An index generated by the subroutine BLOCN that indicates the relative location of the roadway segment and the receiver to the barrier.

DELTA - A distance defined as either -0.50 or -0.51 feet and used by subroutine MOVE to shift points.

XDUM(I)- A dummy point initially set equal to X4V(I).

Output parameters

KTRIG - An index of whether or not the sound from a road segment may be attenuated by a barrier strip. If KTRIG = 0, the segment (X1V, X2V) is unaffected by the strip X4V, X5V (see Output parameter X2V(I)). If KTRIG = 1, the line segment (X1V, X6V) is totally affected by the strip

(X4V, X5V) and the segment (X6V, X2V) is unaffected by the strip (X4V, X5V) (See Output parameter,X6V(I)).

IERR - An error code set by subroutine MOVE. If IERR = 0, the subroutine MOVE has been successful and output from ENDPT can be used. If IERR = 4, the subroutine MOVE has not been successful and output from ENDPT are probably in error. (See Subroutine MOVE).

X1V(I) - One end point of the roadway segment. The input values of X1V(I) are not altered by the subprogram.

X2V(I) - One end point of the roadway segment. The input values of X2V(I) to ENDPT may be altered by ENDPT so that when KTRIG = 0, the roadway segment defined by (X1V, X2V) is not affected by the barrier strip defined by (X4V, X5V). If KTRIG = 1, the input values of X2V(I) to ENDPT are not altered by the subroutine. Hence, the output values of X2V(I) always represent an end point of a roadway segment that is unaffected by the intervening barrier strip.

X3V(I) - Input values of the receiver location. Not altered by the subprogram.

X4V(I), X5V(I) - Input values of the barrier strip location. Not altered by the subprogram.

X6V(I) - If KTRIG = 0, the point X6V has no significance. If KTRIG = 1, the point X6V is a point on the roadway segment (X1V, X2V) that defines a totally affected segment (X1V, X6V) and a totally unaffected segment (X6V, X2V). The point X6V may coincide with the point X2V.

SUBROUTINE ENDPT (X1V, X2V, X3V, X4V, X5V, X6V, DTRIG, IERR) Concluded

RESTRICTIONS: The subroutine ENDPT determines whether or not the roadway segment defined by the input values of (X1V, X2V) is affected by the barrier strip (X4V, X5V) using x-y coordinate geometry. Hence, the subroutine ENDPT does make an absolute judgement as to no effect if KTRI = 0 on the segment (X1V, X2V) or if KTRI = 1 on the segment (X6V, X2V). However, if KTRI = 1, the subroutine does not consider the elevations of source, barrier, and receiver for the roadway segment (X1V, X6V). The usage should recognize this fact.

ACCURACY: That of subprograms.

SIZE: 1152

REFERENCES: None.

3.15 FUNCTION HEIGHT (X1V,X2V,X3V,X4V)

PURPOSE: To calculate the difference in elevation (z coordinates) between the lines defined by the points (X1V, X2V) and (X3V, X4V) at the x-y plane intersection point of the x-y plane projections of the lines (X1V, X2V) and (X3V, X4V).

SUBPROGRAMS USED: INTCPT (X1, X2, X3, X4, X5) ZCOR (X1, X2, X3).

VARIABLES: Input parameters

X1V(I), X2V(I) - Two points defining a line in x(I = 1), y(I = 2), z(I = 3) coordinates.

X3V(I), X4V(I) - Two points defining a line in x(I = 1), y(I = 2), z(I = 3) coordinates.

Subprogram parameters

XI(I) - The x-y plane intersection point of the x-y plane projections of lines defined by the points (X1V, X2V) and (X3V, X4V). Note XI(3) is never assigned a value.

Output parameters

HEIGHT - Difference in elevation between lines defined by (X1V, X2V) and (X3V, X4V) at intersection point.

RESTRICTIONS: That of subprograms used. Hence, HEIGHT can be an elevation difference at a location not on the line segment defined by (X1V, X2V) and (X3V, X4V). See Subprograms INTCPT and ZCOR.

ACCURACY: If the x-y plane projections of the lines (X1V, X2V) and (X3V, X4V) are parallel on collinear HEIGHT will be a very large number. See Subprograms INTCPT and ZCOR.

SIZE: 518

REFERENCES: See Subprograms INTCPT and ZCOR.

3.16 FUNCTION IEPS (X1V,X2V,X3V,X4V,DEL1)

PURPOSE: The decision parameter IEPS represents a comparison of two path length differences, DEL1 and DEL2, to decide whether or not the path length differences are sufficiently similar so that the condition of uniform sound intensity from a roadway segment to a receiver via a diffracted path over a barrier exists. If IEPS = 0, the condition of uniform sound intensity at the receiver is satisfied and DEL2 is considered similar to DEL1. If IEPS = 1, DEL2 is not sufficiently similar to DEL1 for uniform sound intensity at the receiver to be assumed.

SUBPROGRAMS USED: AMAG(X1, X2), HEIGHT(X1, X2, X3, X4), DEL(X1, X2, X3, X4), HDIFF, DIST.

VARIABLES: Input parameters

X1V(I) - A point in (x, y, z) coordinate space that represents the source.

X2V(I) - A point in (x, y, z) coordinate space that represents the receiver.

X3V(I), X4V(I) - Two points in (x, y, z) coordinate space that define a line representing the top of a barrier.

DEL1 - A number representing a path length difference for an acoustic propagation path diffracting over a barrier.

Subprogram parameters

DIST - The distance between the source point X1V(I) and the receiver point X2V(I).

HDIFF - The elevation difference (difference in z coordinates) between points on the lines defined by the points X1V, X2V and X3V, X4V at the x-y plane intersection point of these lines (See RESTRICTIONS).

FUNCTION IEPS (X1V, X2V, X3V, X4V, DEL1) Concluded

DEL2 - The path length difference defined by the source location, X1V; the receiver location, X2V; and the top of a barrier defined by the line through the points X3V, X4V. (See RESTRICTIONS and Subprogram DEL).

DELM - The arithemetic average of the values of DEL1 and DEL2.

Output parameter

IEPS - IEPS = 0 if the values of DEL1 and DEL2 satisfy the cirterion presented under REFERENCES. (See PURPOSE) IEPS = 1 if the values of DEL1 and DEL2 do not satisfy the criterion presented under REFERENCES. (See PURPOSE).

RESTRICTION: Neither the subprogram IEPS nor any of the subprograms utilized by IEPS checks to see if the line segment (X1V, X2V) intersects the line segment (X3V, X4V). For proper utilization this subprogram must receive input data such that the above line segments do intersect and that the variable DEL1 corresponds to a path length difference associated with the input data geometry. Usage should recognize this restriction. (See Subprogram DEL).

ACCURACY: That of subprograms used and the criterion specified. (See REFERENCES).

SIZE: 700

REFERENCES: The criterion used to judge similarity of two path length differences is that

$$|\delta_2 - \delta_1| - \frac{(\delta_2 + \delta_1)}{100} (1 + (\delta_2 + \delta_1)/2) \leq 0.10$$

Where δ_1 = DEL1, δ_2 = DEL2. See description of barrier diffraction under Prediction Model in main text of report.

3.17 SUBROUTINE IMAGE (X1V,X2V,X3V,X4V)

PURPOSE: To calculate the (x, y, z) (I = 1,2,3) location of an image receiver at the point X4V(I) relative to a receiver at the point X3V(I) and a reflector defined by the end points X1V(I) and X2V(I). All calculations are conducted in the x-y plane with the z coordinate, X4V(3), of the image receiver set equal to the z coordinate X3V(3) of the receiver.

SUBPROGRAMS USED: None.

VARIABLES:

Input parameter

X1V(I), X2V(I) - The x, y, z coordinates of the reflector.
X3V(I) - The x, y, z coordinates of the receiver.

Subprogram parameters

AX - The x-component of the directed line segment (X1V, X2V)
AY - The y-component of the directed line segment (X1V, X2V).
AXY - The square of the distance of the x-y plane projection of the line segment (X1V, X2V).
RATIO - The ratio of the x-y plane projections of the distance of point X3V from the line defined by X1V, X2V to the length of the line segment (X1V, X2V).

Output parameters

X4V(I) - The (x, y, z) coordinates of the image receiver.

RESTRICTIONS: The subroutine does not utilize the z coordinates defining the reflector and, hence, cannot judge whether or not a reflection would in fact occur. Usage should recognize this restriction.

ACCURACY: Not applicable.

SIZE: 532

REFERENCES: See Figure 3-4 for nomenclative.

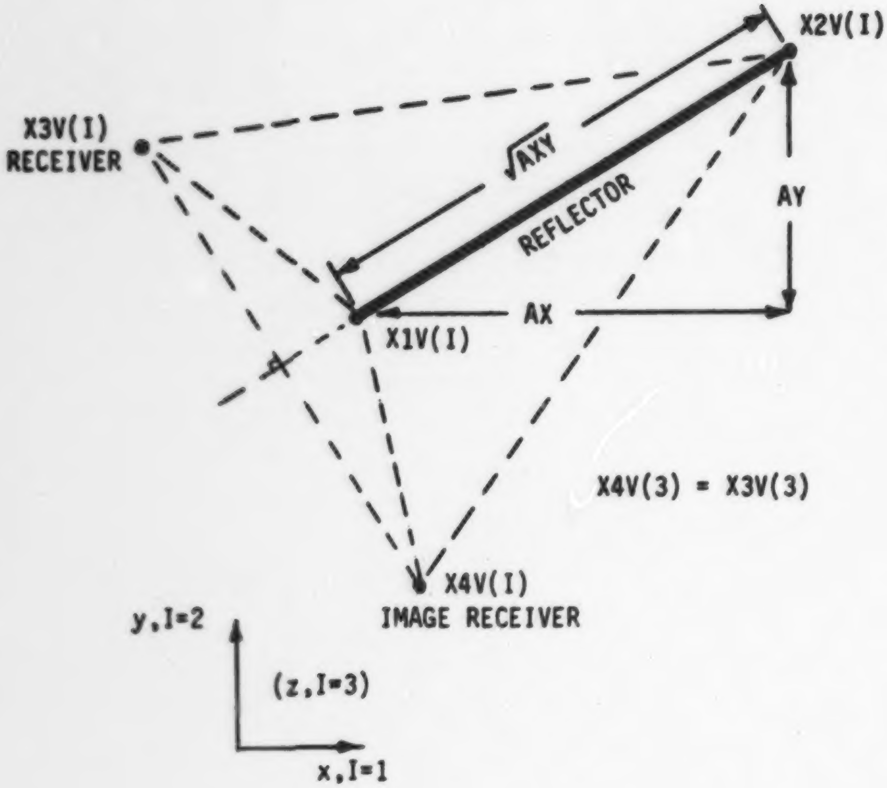

FIGURE 3-4. SUBROUTINE IMAGE: NOMENCLATURE

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3.18 SUBROUTINE INTCPT (X1V,X2V,X3V,X4V,X5V)

PURPOSE: To calculate the x-y plane intersection point, X5V(I), of two lines defined by the points (X1V(I)), and (X2V(I)), and (X3V(I)), (X4V(I)). The subscript I = 1 for x-coordinates and I = 2 for y-coordinates.

SUBPROGRAMS USED: None.

VARIABLES: Input parameters

X1V(I), X2V(I) - Points in the x-y plane defining a line.
X3V(I), X4V(I) - Points in the x-y plane defining a line.

Subprogram parameters

AX, AY - x-component and y-component respectively, of the line segment defined by (X1V, X2V).
BX, BY - x-component and y-component respectively of the line segment defined by (X3V, X4V).
C1, C2 - Algebraic expressions arising in the derivation of the algorithm.
D - The value of the 2X2 determinant formed by the x,y components of the two line segments.

Output parameters

X5V(I) - The (x,y) coordinate (I = 1, I = 2, respectively) of the intersection point.

RESTRICTIONS: If either line segment has zero length, then D = 0 and a division by zero will occur. If the two line segments are parallel or coincide, D = 0 and a division by zero will occur. If $D^2 < 10^{-6}$ ft^2, the subroutine, projects the point X5V out in the x-y plane somewhere beyond a radius of 2×10^{14} miles from the point X1V. Usage should recognize these restrictions.

ACCURACY: See Restrictions.

SIZE: 738

SUBROUTINE INTCPT (X1V, X2V, X3V, X4V, X5V) Concluded

REFERENCES: The algorithm used to calculate the point X5V, is derived by writing the vector equation for lines passing through the points (X1V, X2V) and (X3V, X4V) and solving for their common point.

[redacted]

3.19 FUNCTION KCUT (X1V,X2V,X3V,X4V)

PURPOSE: To calcualte a logic number, KCUT, that indicates whether or not two line segments intersect in the x-y plane. The line segments are defined by the end points (X1V, X2V) and (X3V, X4V). If the line segments intersect (including end points) KCUT = 1. Otherwise, KCUT = 0.

SUBPROGRAMS USED: INTCPT (X1, X2, X3, X4, X5), KPOS (X1, X2, X3).

VARIABLES: Input parameters

X1V(I), X2V(I) - Points in the x-y plane defining a line segment. The subscript I = 1 for x-coordinates; I = 2 for y-coordinates.

X3V(I), X4V(I) - Points in the x-y plane defining a line segment. The subscript I = 1 for x-coordinates; I = 2 for y-coordinates.

Output parameters

KCUT = 1 - if the line segments intersect in an oblique sense including end points.

KCUT = 0 - if the line segments do not intersect or are collinear.

RESTRICTIONS: If the line segments are collinear, KCUT = 0. See Subprogram INTCPT. Usage should recognize this restriction.

ACCURACY: Not applicable.

SIZE: 544

REFERENCES: None.

3.20 FUNCTION KPOS (X1V,X2V,X3V)

PURPOSE: To calculate a logic number, KPOS, indicating whether the point X3V, in the x-y plane lies on a line segment defined by the points X1V, X2V in the x-y plane. If X3V lies on the line segment (including the end points) KPOS = 1. If X3V does not lie on the line segment KPOS = 0. (See RESTRICTIONS).

SUBPROGRAMS USED: None.

VARIABLES: Input parameters

X3V(I) - A point in the x-y plane defined by the x-coordinate (I = 1) and the y-coordinate (I = 2).

X1V(I), X2V(I) - Points in the x-y plane defined by the x-coordinate (I = 1) and the y-coordinate (I = 2).

Output parameters (SEE RESTRICTIONS)

KPOS = 1 - If X3V lies on the line segment X1V, X2V.

KPOS = 0 - If X3V does not lie on the line segment X1V, X2V.

RESTRICTIONS: The criteria used to judge if X3V is on the line is $\vec{R}_{12} \cdot \vec{R}_{23} > 0$. Hence, it is possible for X3V to lie off the line segment and still obtain KPOS = 1. Usage should recognize this fact.

ACCURACY: See RESTRICTIONS.

SIZE: 390

REFERENCES: None.

3.21 SUBROUTINE MIDP (X1V,X2V,X3V)

PURPOSE: To calculate the midpoint, X3V, of a line segment defined by the points (X1V, X2V) in x, y, z coordinate space.

SUBPROGRAMS USED: None.

VARIABLES: Input parameters

X1V(I), X2V(I) - Points in x, y, z coordinate space defining the line segment.

I - Subscript defining the
    x - component I = 1
    y - component I = 2
    z - component I = 3
  of the points X1V(I), X2V(I), X3V(I).

Output parameter

X3V(I) - Point in x, y, z coordinate spece defining the midpoint of the line segment (X1V, X2V).

RESTRICTIONS: None

ACCURACY: Not applicable

SIZE: 402

REFERENCES: None

3.22 SUBROUTINE NRPT (X1V, X2V, X3V, X4V, DIST) Continued

PURPOSE: To compute the point X4V on a line defined by the points X1V, X2V that is nearest to the point X3V. The length of the line segment (X3V, X4V) is the distance, DIST, from the point X3V to the line defined by X1V, X2V. If DIST =0, then DIST is set equal to 1 foot prior to returning to the calling program.

SUBPROGRAMS USED: DSQR (X1,X2); AMAG (X1, X2)

VARIABLES: Input Parameters

X1V(I), X2V(I) - Points in x, y, z coordinate space defining a line.

X3V(I) - A point in the x, y, z coordinate space.

Subprogram Parameters

I - Subscript denoting coordinate
x - coordinate, I = 1
y - coordinate, I = 2
z - coordinate, I = 3

AV(I) - Components of vector $\vec{R}_{21}$

BV(I) - Components of vector $\vec{R}_{31}$

AX, AY, AZ - Values of AV(1), AV(2), AV(3); respectively.

BX, BY, BZ - Values of BV(1), BV(2), BV(3); respectively.

TEMP - Square of length of line segment defined by X1V, X2V.

SUBROUTINE NRPT (X1V, X2V, X3V, X4V, DIST) Concluded

RATIO - An expression developed in the derivation of the point X4V(I) in terms of X1V(I), X2V(I) and X3V(I).

Output Parameters

X4V(I) - A point on the line defined by X1V(I), X2V(I) that is nearest to the point X3V(I). See RESTRICTIONS.

DIST - The distance from the point X3V(I) to the line defined by X1V(I), X2V(I). If DIST = 0, the subprogram sets DIST = 1 prior to returning control to tne calling program. See RESTRICTIONS.

RESTRICTIONS: If the points X1V and X2V coincide, X4V coincides with X1V and DIST is the distance between X3V and X4V. If X3V is on the line defined by X1V, X2V then X4V and X3V coincide and DIST = 1.

REFERENCES: None.

SIZE: 796

3.23 SUBROUTINE NR1 (X1V, X2V, X3V, X4V, DIST, X5V, DN1)

PURPOSE:	To calculate the point, X5V, on the line segment (X1V, X2V) that is nearest to the point X3V and to calculate the distance between the points X3V and X5V.
SUBPROGRAMS USED:	KPOS (X1, X2, X3), REPLCE (X1, X2), AMAG (X1, X2)

VARIABLES:

Input Parameters

X1V(I), X2V(I) - Points in (x, y, z) coordinate space defining a line segment and a line.

X3V(I) - A point in (x, y, z) coordinate space.

X4V(I) - The point on the line passing through the points X1V, X2V that is nearest to the point X3V.

DIST - The distance from the point X3V to the line passing through the points X1V, X2V.

Output Parameters

X5V(I) - A point on the line segment (X1V, X2V) that is nearest to the point X3V.

DN1 - The length of the line segment (X3V, X5V).

RESTRICTIONS: See Subprogram NRPT.

ACCURACY: Not Applicable.

SIZE: 736

REFERENCES: None.

3.24 SUBROUTINE REPLCE (X1V,X2V)

PURPOSE: To assign the coordinates of a point or the components of a vector, X1V(I), to the coordinates of a point or the components of a vector X2V(I). The values of X1V(I) are unchanged.

SUBPROGRAMS USED: None.

VARIABLES: Input/Output Parameters

X1V(I), X2V(I) - The components of two vectors or the coordinates of two points in (x, y, z) coordinate space.

x - component or coordinate I = 1
y - component or coordinate I = 2
z - component or coordinate I = 3

RESTRICTIONS: None.

ACCURACY: Not applicable.

SIZE: 310

REFERENCES: None.

3.25 SUBROUTINE SECTN (X1V, X2V, X3V, X4V, X5V, X6V, X7V)

PURPOSE: Calculates the (x, y, z) coordinates of the points X6V(I) and X7V(I). The point X6V(I) is on the line passing through the points X4V, X5V intersecting the vertical (z - coordinate) plane defined by the (x-y) coordinates of the points X1V, X3V. The point X7V is on the line passing through the points X4V, X5V intersecting the vertical (z - coordinate) plane defined by the (x-y) coordinates of the points X2V, X3V. (See RESTRICTIONS and Figure 3-5.

SUBPROGRAMS USED: INTCPT (X1, X2, X3, X4, X5), ZCOR (X1, X2, X3)

VARIABLES: Input Parameters

X1V(I), X2V(I), X3V(I) - Points in (x, y, z) coordinate space defining lines passing through the points X1V, X3V and X2V, X3V.

X4V(I), X5V(I) - Points in the (x, y, z) coordinate space defining a line passing through the points X4V, X5V.

Output Parameters

X6V(I), X7V(I) - Points on the line passing through the points X4V, X5V that lie in the vertical plane defined by the x-y components of the lines passing through the points X1V, X3V and X2V, X3V, respectively.

RESTRICTIONS: The subprogram does not check to see if the points X6V and X7V lie on the line segment (X4V, X5V). Usage of this subprogram must recognize this restriction.

ACCURACY: See Subprogram INTCPT.

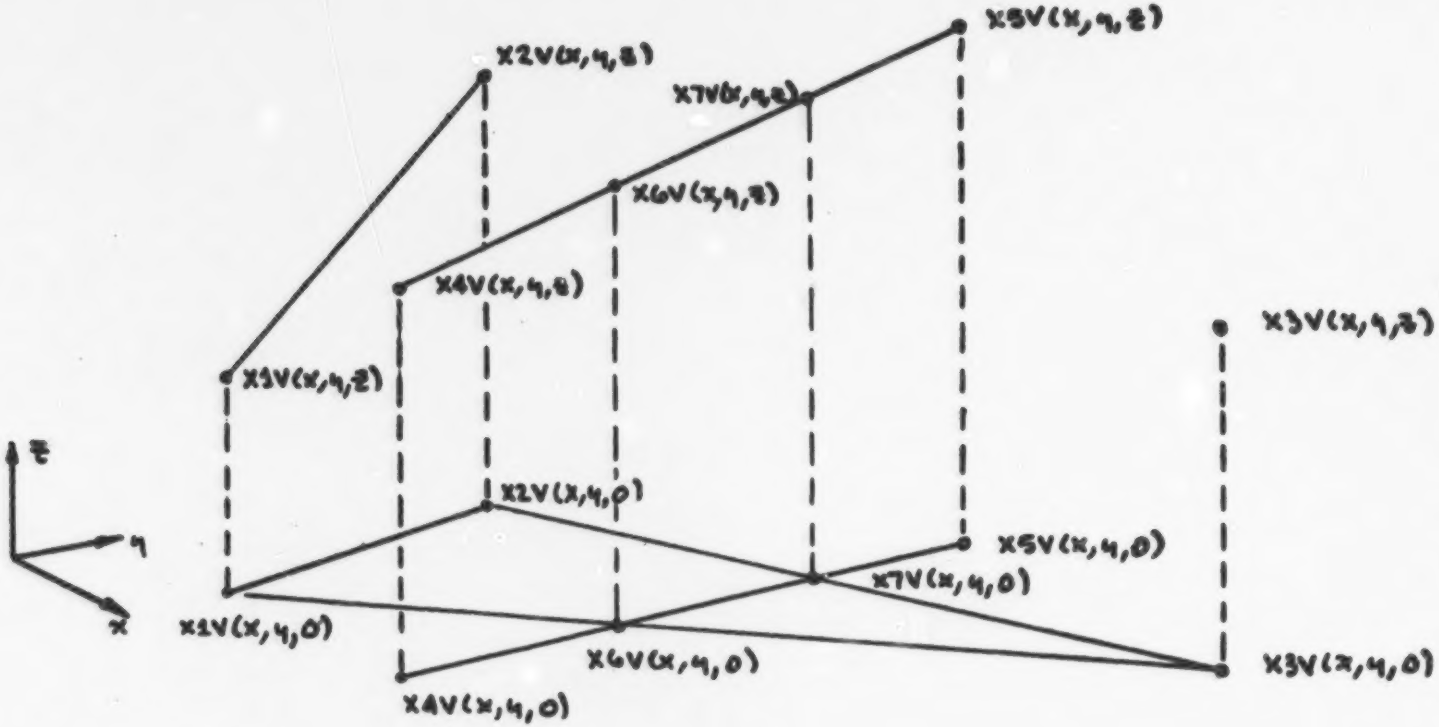

FIGURE 3-5 SUBROUTINE SECTN: NOMENCLATURE

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SUBROUTINE SECTN (X1V, X2V, X3V, X4V, X5V, X6V, X7V) **Concluded**

SIZE: 634

REFERENCES: None.

3.26 SUBROUTINE TRI (X1V, X2V, X3V, X4V, X5V, KTRI)

PURPOSE: To calculate a logic number, KTRI, that indicates whether or not the point X4V lies within or on the boundaries of a triangle in the x-y plane formed by the points X1V, X2V, and X3V. (See VARIABLES and RESTRICTIONS).

SUBPROGRAMS USED: INTCPT (X1, X2, X3, X4, X5); KPOS (X1, X2, X3)

VARIABLES: Input Parameters

X1V(I), X2V(I), X3V(I) - The coordinates of three points in the x-y plane. The x-coordinate is denoted by I = 1; the y-coordinate by I = 2.

X4V(I) - A point in the x-y plane whose location relative to the triangle formed by the points X1V, X2V, X3V is to be determined.

Output Parameters

X5V(I) - The intersection point of the lines through X1V, X2V and X3V, X4V.

KTRI - A logic number that indicates the location of X4V relative to the triangle formed by the points X1V, X2V, X3V.

KTRI = 1 If the point X4V lies interior to or on the boundary of (excluding the point X3V) the triangle formed by the points X1V, X2V, X3V.

KTRI = 0 If the point X4V coincides with the point X3V or lies exterior to the triangle formed by the points X4V, X2V, X3V.

SUBROUTINE TRI (X1V, X2V, X3V, X4V, X5V, KTRI) Concluded

RESTRICTIONS: The intersection point X5V is always calculated and returned to the calling program. If KTRI = 1 the point X5V lies on the line segment defined by the end points X1V, X2V including the end points. If KTRI = 0 and X4V does not coincide with X3V, the point X5V lies on the line passing through the points X1V, X2V. If the points X3V and X4V coincide KTRI = 0 and X5V is projected to a point beyond $2 \cdot 10^{14}$ miles from the point X1V. (See Subprogram INTCPT). Usage of this subroutine should recognize these restrictions.

ACCURACY: That of subprograms.

SIZE: 594

REFERENCES: None.

3.27 FUNCTION ZCOR (X1V,X2V,X3V)

PURPOSE: To calculate the z - coordinate, X3V(3), of a point X3V(I) on a line defined by the points X1V(I) and X2V(I).

SUBPROGRAMS USED: None.

VARIABLES: Input Parameters

X1V(I), X2V(I) - Points in (x, y, z) coordinate space defining a line.

X3V(1), X3V(2) - The x-coordinate and the y-coordinate of the point X3V. (See RESTRICTIONS).

Output Parameter

X3V(3) - The z-coordinate of the point X3V. (See RESTRICTIONS).

RESTRICTIONS: The subroutine does not check to see if the x-y coordinates of X3V fall on the x-y plane projection of the line through the points X1V, X2V. Usage of the subroutine should reflect this restriction.

The points X1V, X2V must neither coincide nor define a line parallel to the z-axis.

ACCURACY: Not applicable.

SIZE: 490

REFERENCES: None.

3.28 SUBROUTINE MOVE (X1V, X2V, X3V, DELTA, IERR)

PURPOSE: To calculate the coordinates of the point X2V that lies on a line passing through the points X1V, X3V and is a specified distance, DELTA, from the point X1V in (x, y, z) coordinate space. (See VARIABLES, DELTA).

SUBPROGRAMS USED: AMAG (X1, X2)

VARIABLES:

Input Parameters

X1V(I), X3V(I) - Points in (x, y, z) coordinate space defining a line.

x - coordinate I = 1
y - coordinate I = 2
z - coordinate I = 3

DELTA - The distance from the point X1V at which one desires the point X2V to be located on the line X1V, X3V. If DELTA is positive, X2V will be located along the line defined by X1V, X3V in the direction from X3V to X1V. If DELTA is negative, X2V will be located along the line defined by X1V, X3V in the direction from X1V to X3V. If DELTA is zero, X2V will coincide with X1V.

Subprogram Parameters

TEMP - The length of the line segment defined by the points X1V, X3V.

FCTR - The ratio of DELTA to TEMP

Output Parameters

X2V(I) - The x, y, z coordinates of the point X2V.

IERR - An error indicator. If TEMP is greater than zero (i.e., X1V and X3V do not coincide) then IERR = 0. If TEMP is equal to zero (i.e., X1V and X3V coincide) then IERR = 4 and the point X2V(I) is not calculated when control is returned to the calling program.

RESTRICTIONS: See description of variable IERR.

ACCURACY: Not applicable.

SIZE: 582

REFERENCES: The point X2V is calculated using the vector relation

$$\vec{R}_2 = \vec{R}_1 + \text{DELTA}\ \vec{r}_{31}$$

$$\vec{r}_{31} = \vec{R}_{31} / \sqrt{\vec{R}_{31} \cdot \vec{R}_{31}}$$

3.29 SUBROUTINE MOVE2 (X1V, X2V, X3V, DELTA, IERR)

PURPOSE: To calculate, in the x-y plane, the coordinates of the point X2V that lies on a line passing through the points X1V, X3V and is a specified distance, DELTA, from the point X1V. This is the x-y plane analogue of subroutine MOVE.

SUBPROGRAMS USED: None.

VARIABLES:

Input Parameters

X1V(I), X3V(I) - Points in the x-y plane defining a line.

x - coordinate I = 1

y - coordinate I = 2

DELTA - The distance from the point X1V at which one desires to locate the point X2V on the line defined by the points X1V, X3V. If DELTA is positive, X2V will be located on the line defined by X1V, X3V in the direction from X3V to X1V. If DELTA is negative, X2V will be located along the line defined by X1V, X3V in the direction from X1V to X3V. If DELTA is zero, X2V coincides with X1V.

Subprogram Parameters

TEMP - The length of the line segment defined by the points X1V, X3V.

FCTR - The ratio of DELTA to TEMP.

Output Parameters

X2V(I) - The x,y coordinates of the point X2V.

SUBROUTINE MOVE2 (X1V, X2V, X3V, DELTA, IERR) Concluded

IERR - An error indicator. If TEMP is greater than zero (i.e., X1V and X3V do not coincide), then IERR = 0 and the coordinates, X2V(I) are calculated. If TEMP is zero (i.e., X1V and X3V coincide), then IERR = 4 and the coordinates, X2V(I), are not calculated.

RESTRICTIONS: See description of variable IERR.

ACCURACY: Not applicable.

REFERENCES: See Subroutine MOVE.

SIZE: 596

3.30 SUBROUTINE COLIN (X1V,X2V,X3V)

PURPOSE: The subroutine checks to see if the point X3V is colinear with the points X1V, X2V in the x-y plane. The x-y coordinates of the point X3V are altered by the subroutine so that the point X3V is not colinear with points X1V, X2V, if the points are judged to be collinear.

SUBPROGRAMS USED: IAREA (X1V, X2V, X3V), ANGLE (X1V, X2V, X3V)

VARIABLES: Input Parameters

X1V(I), X2V(I), X3V(I) - Three points in the x-y plane defined by their components.

x - component I = 1

y - component I = 2

Subprogram Parameters

ANG - The angle between the line segments (X1V,X3V) and (X2V, X3V).

Output Parameters

X3V(I) - The components of a point in the x-y plane, X3V(I),that is near to the input values X3V(I) but that is not considered by the routine to be colinear with the points X1V, X2V. (See RESTRICTIONS).

RESTRICTIONS: The criteria used to judge whether or not X3V is colinear with X1V, X2V is the area of the triangle formed by the points X1V, X2V, X3V and, possibly, the magnitude of the variable ANG.

SUBROUTINE COLIN (X1V, X2V, X3V) Concluded

ACCURACY: That of the criteria.

SIZE: 738

REFERENCES: See Subprograms IAREA and ANGLE.

3.31 FUNCTION IAREA (X1V,X2V,X3V)

PURPOSE: To calculate an index, IAREA, that indicates the relative spacing (area enclosed) of the three points X1V, X2V, X3V in the x-y plane.

SUBPROGRAMS USED: None.

VARIABLES:

Input Parameters

X1V(I), X2V(I), X3V(I) - Points defined in the x-y plant.

x - coordinate I = 1

y - coordinate I = 2

Subprogram Parameters

TERM 1, TERM 2, TERM 3 - The three terms resulting from calculating the vector ("cross") product of the vectors R_{31} and R_{32}.

AREA - A number equal to twice the area of the triangle formed by the points X1V, X2V, X3V. If AREA is zero, the points X1V, X2V, X3V, are colinear. (See REFERENCES).

Output Parameters

IAREA:IAREA = 1 if the area of the triangle formed by X1V, X2V, X3V is greater than 1 square foot, or if AREA is negative.

IAREA = 0 if the area of the triangle formed by X1V, X2V, X3V is equal to or greater than zero square feet but less than or equal to 1 square foot.

FUNCTION IAREA (X1V, X2V, X3V) Concluded

RESTRICTIONS: None.

ACCURACY: Not applicable.

SIZE: 486

REFERENCES: The variable AREA is the magnitude of the vector formed by the vector product of the vectors $\vec{R}_{31}$ and $\vec{R}_{32}$ in the x-y plane.

3.32 SUBROUTINE DEGEN (X1V, X2V, X3V, X4V, X5V, LOC)

PURPOSE: This subroutine preprocesses data for subroutine BLOCN to ensure that degenerate geometrical alignments between the points X1V, X2V, X3V and a line segment X4V, X5V that may confuse the logic of subroutine BLOCN do not occur. Physically, the line segment defined by the x(I=1) and y(I=2) coordinates of the points X1V(I) and and X2V(I) represents a road segment, the point X3V(I) represents a receiver, and the line segment defined by the points X4V(I) and X5V(I) represent a barrier.

THIS SUBROUTINE SHOULD BE USED ONLY AS A PREPROCESSOR FOR SUBROUTINE BLOCN.

SUBPROGRAMS USED: IAREA (X1V, X2V, X3V), MOVE2 (X1V, X2V, X3V, DELTA, IERR)

VARIABLES: Input Parameters

X1V(I), X2V(I) - Points defining a road segment location in the x(I=1), y(I=2) plane.

X3V(I) - A point defining the receiver location in the x(I=1), y(I=2) plane.

X4V(I), X5V(I) - Points defining a barrier or ground strip location in the x,y plane. See Output Parameters.

Output Parameters

LOC A logic parameter indicating the relative alignment of the line segment (X4V, X5V) with the line segments (X1V, X3V) and (X2V, X3V). LOC = 0 or 3 or 5.

LOC = 3 indicates that point X4V is colinear with (X1V, X3V) and that point X5V is colinear with (X2V, X3V) or that point X4V is colinear with (X2V, X3V) and that point X5V is colinear with (X1V, X3V). That is, the line segment (X4V, X5V) exactly blocks the (x, y) plane line-of-sight from the receiver X3V to the roadway (X1V, X2V).

LOC = 5 indicates that either point X4V or X5V was determined to be colinear with one of the segments (X1V, X3V) or (X2V, X3V) or neither point X4V or X5V was colinear with one of the segments (X1V, X3V) or (X2V, X3V). If either X4V or X5V was determined to be colinear, the point is relocated by subroutine MOVE2 decreasing the length of the segment (X4V, X5V) by 1 foot.

X4V(I), X5V(I) - If LOC = 5, either X4V(I) or X5V(I) may be relocated as indicated above so that X4V(I) or X5V(I) is not collinear with the segments (X1V, X3V) or (X2V, X3V).

RESTRICTIONS: This subroutine should be used only as a preprocessor for subroutine BLOCN. See listing of subroutine GEOMRY for usage.

If an error occurs in subroutine MOVE2, the following message is printed: "ERROR IN MOVE2". This error will

SUBROUTINE DEGEN (X1V, X2V, X3V, X4V, X5V, LOC) Concluded

not be, quite likely, fatal but the user should check results closely.

ACCURACY: See RESTRICTIONS.

SIZE: 1096

REFERENCES: None.

3.33 SUBROUTINE GEOMRY (XR,YR,ZR,XR10,XR20,IERR,MR,MRC,GAM)

PURPOSE

This subroutine conducts the bulk of the calculation effort of the highway traffic noise prediction code. Basically, subroutine GEOMRY considers a receiver location defined by the coordinates XR, YR, ZR and a straight line roadway segment defined for roadway number MR with end points XR10 and XR20. This defines the basic roadway/receiver geometry and traffic flow conditions as indicated in Appendix A of the User's Manual, Figure A-1. The error code, IERR, is generated in subroutines MOVE and MOVE2 (IERR=4) or if too many reflections have occurred (IDXR greater than 11, IERR = 3).

Using the basic assumption of uniform reception of acoustic intensity at the receiver location, subroutine GEOMRY considers attenuation by barrier diffraction or ground absorption or amplification by reflection from barriers. It is an understatement to say that the subroutine is complex. Subroutine GEOMRY considers all site-related geometric and acoustic parameters to estimate the normalized acoustic intensity (Equation A-9) and the normalized value of the cumulant, κ_2^* (Equation A-11) at a receiver for a straight line roadway segment. Subroutine GEOMRY is called by the MAIN PROGRAM for all segments defining a roadway and for all roadways for each receiver location (See Figure 2-2). The summation of acoustic intensity and calculation of the cumulant at each receiver is accomplished by the call statement to GEOMRY from the MAIN PROGRAM and branching internal to GEOMRY. Consideration of vehicle types and spectra calculations defined by the user are conducted internally in subroutine GEOMRY. The vast bulk of data utilized by GEOMRY is transferred through the various COMMON data blocks (See Sec. 5).

The basic organization of subroutine GEOMRY is illustrated in Figure 3-6. For the basic roadway/receiver geometry (a plane triangle defined by the end points of the roadway segment and the receiver),

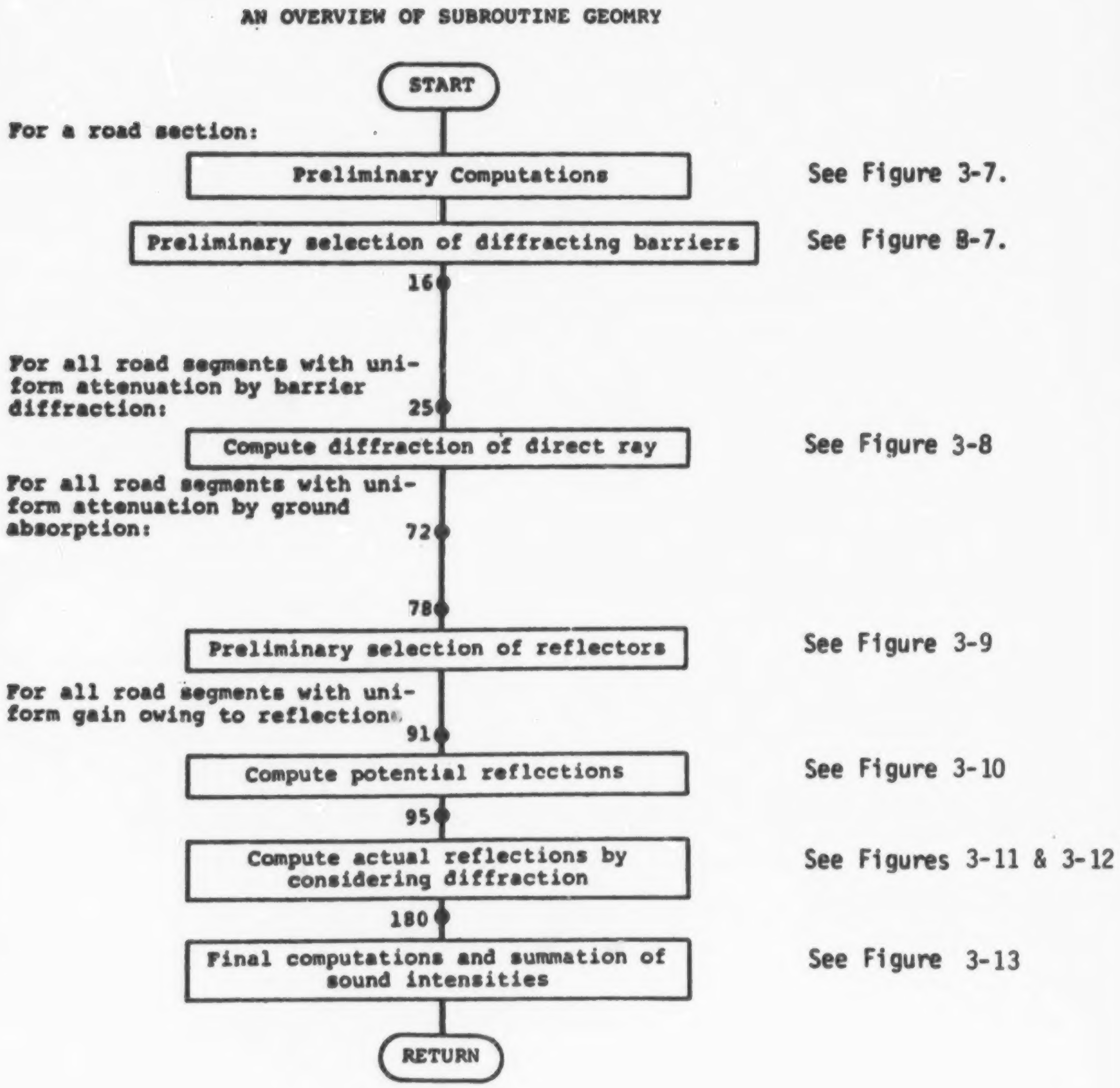
AN OVERVIEW OF SUBROUTINE GEOMRY
START
For a road section:
Preliminary Computations
See Figure 3-7.
Preliminary selection of diffracting barriers
See Figure B-7.
16
For all road segments with uniform attenuation by barrier diffraction:
25
Compute diffraction of direct ray
See Figure 3-8
For all road segments with uniform attenuation by ground absorption:
72
78
Preliminary selection of reflectors
See Figure 3-9
For all road segments with uniform gain owing to reflection:
91
Compute potential reflections
See Figure 3-10
95
Compute actual reflections by considering diffraction
See Figures 3-11 & 3-12
180
Final computations and summation of sound intensities
See Figure 3-13
RETURN

FIGURE 3-6. SUBROUTINE GEOMRY: OVERVIEW

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GEOMRY checks during the preliminary calculations to see if barrier segments lie interior to the x-y plane projection of the roadway/ receiver triangle. Using only x-y plan geometry, segments, or portions of segments of barriers are identified as "potential" diffractions which are stored for a more detailed analysis. The detailed consideration of diffraction is accomplished by GEOMRY using a sequential subdivision of the straight line roadway segment into subsegments, beginning at point XR10. If no barriers, or reflectors have been encountered, no subdivision of the segment XR10, XR20 occurs and the accoustic intensity is calculated from the roadway segment. (Equation (A-3), User's Manual App.). If a potential diffraction has been encountered, the segment (XR10,XR20) is subdivided as indicated in Figure A-1 (c) as an example. For each subsegment potentially affected by a barrier, GEOMRY further subdivides the raodway segment using three-dimensional geometry to determine whether or not the diffraction is significant. For significant diffractions (See Equation (A-21)) the raodway subdivision continues until uniform accoustic intensity at the receiver can be assumed. For each diffraction calculation, GEOMRY retains only the maximum path length difference calculated for each vehicle type (including source height adjustment) to estimate attenuation resulting from diffraction. Subroutine GEOMRY checks first for diffraction, then for reflections to establish the subdivision of a roadway segment. Hence, a roadway segment as defined by the user may be subdivided several times internally by GEOMRY prior to returning to the MAIN PROGRAM.

Flow diagrams are presented in Figures 3-7 through 3-13 illustrating the detail operations and branches of the internal calculations utilized by

GEOMRY for each major consideration presented in Figure 3-6. These flow diagrams are presented at the end of the subroutine description so as not to interrupt the flow of text. Statement numbers are shown so that the user may refer to blocks of code in the subroutine listing. The subroutine listing is presented following the flow diagrams.

Figure 3-7 illustrates the preliminary calculations performed by GEOMRY. First, GEOMRY calls subroutine COLIN to insure that the receiver point and the roadway segment are not colinear. Next, GEOMRY calculates the distance, DIST, and the point on the line through the roadway segment end points, XNPT, using subroutine NRPT. The angle, ANG1 , between the normal from the receiver point to the roadway line and the line from the receiver point to the roadway end point, XR10, is calculated using subroutine ANGLE.

As indicated in Figure 3-7 the preliminary selection of barriers is accomplished by calling subroutines DEGEN and BLOCN to determine if barrier segments occurr internally to the x-y plane triangle formed by the roadway segment and receivers. (See Figure 3-2). If a potential barrier is encountered, barrier data is stored internally to GEOMRY. Otherwise, the barrier segment is ignored. All barrier segments are checked for each call to subroutine GEOMRY.

Following the preliminary selection of barriers, GEOMRY then begins the detail calculation of barrier diffraction. The flow diagram for these considerations is presented in Figure 3-8. During this step in the computation the roadway segment being analyzed is subdivided to ensure that uniform reception of acoustic intensity at the receiver occurs (See Equation(A-21)). The path length difference is initialized to ensure that barrier attention is zero (DELPO=-0.2). This initialization corresponds to an octave band center frequency of 500 Hz. The subsegment of roadway being analyzed is carried internally as (XR1,XK).

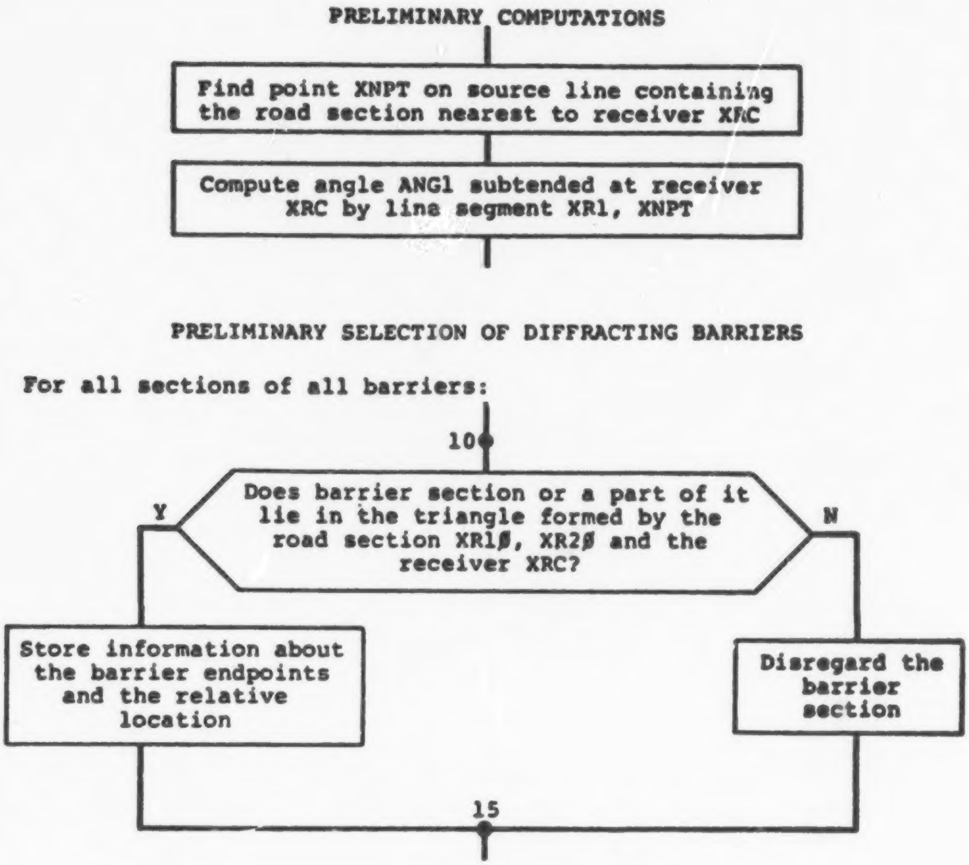
PRELIMINARY COMPUTATIONS
Find point XNPT on source line containing the road section nearest to receiver XRC
Compute angle ANG1 subtended at receiver XRC by line segment XR1, XNPT
PRELIMINARY SELECTION OF DIFFRACTING BARRIERS
For all sections of all barriers:
10
Does barrier section or a part of it lie in the triangle formed by the road section XR10, XR20 and the receiver XRC?
Y
N
Store information about the barrier endpoints and the relative location
Disregard the barrier section
15

FIGURE 3-7. SUBROUTINE GEOMRY: FLOW DIAGRAM OF PRELIMINARY OPERATIONS

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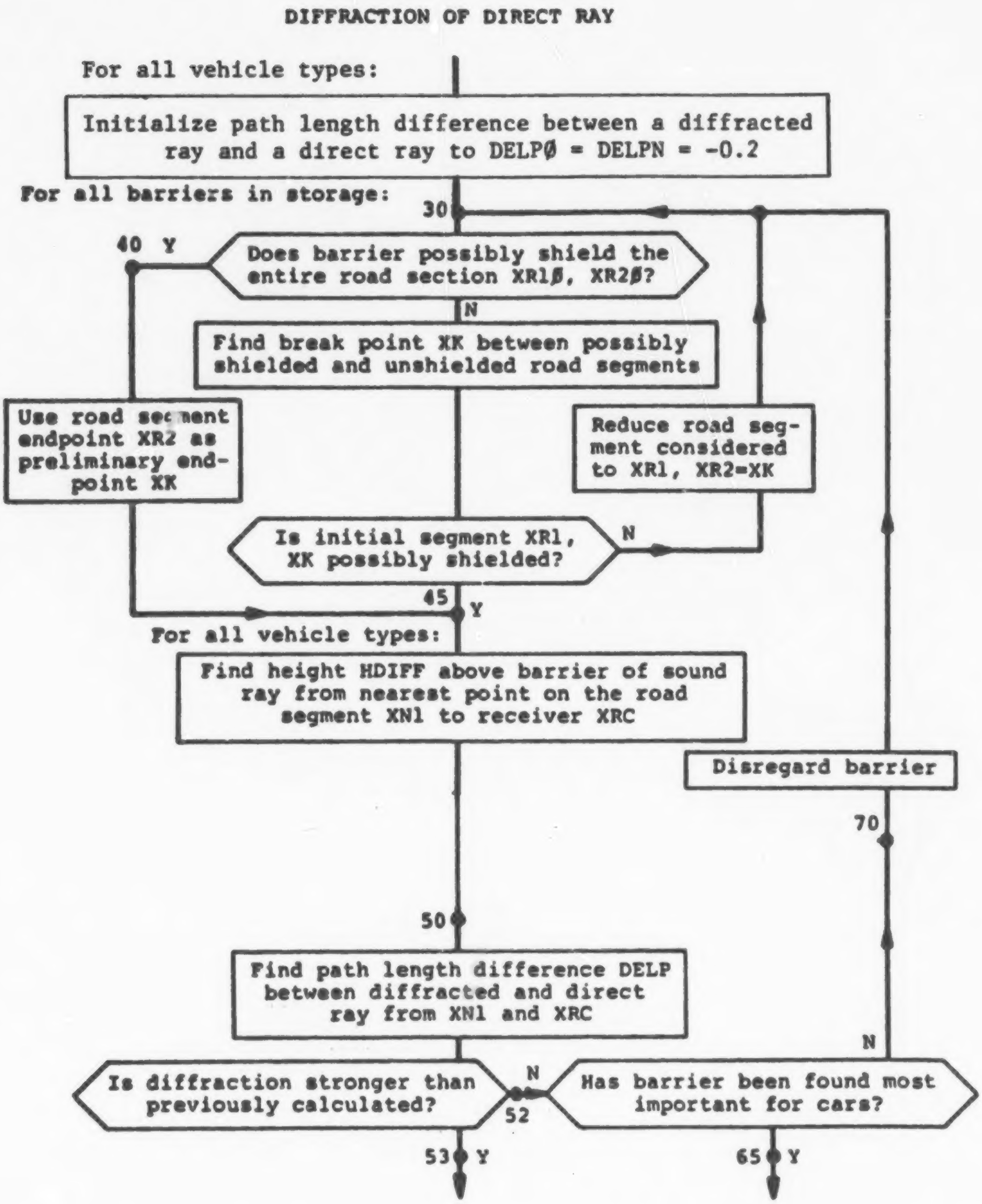
DIFFRACTION OF DIRECT RAY
For all vehicle types:
Initialize path length difference between a diffracted ray and a direct ray to DELP0 = DELPN = -0.2
For all barriers in storage:
30
40 Y
Does barrier possibly shield the entire road section XR10, XR20?
N
Find break point XK between possibly shielded and unshielded road segments
Use road segment endpoint XR2 as preliminary endpoint XK
Reduce road segment considered to XR1, XR2=XK
Is initial segment XR1, XK possibly shielded?
N
45
Y
For all vehicle types:
Find height HDIFF above barrier of sound ray from nearest point on the road segment XN1 to receiver XRC
Disregard barrier
70
50
Find path length difference DELP between diffracted and direct ray from XN1 and XRC
N
Is diffraction stronger than previously calculated?
N
52
Has barrier been found most important for cars?
53 Y
65 Y

FIGURE 3-8. SUBROUTINE GEOMRY: FLOW DIAGRAM OF BARRIER DIFFRACTION CONSIDERATIONS FOR THE DIRECT RAY

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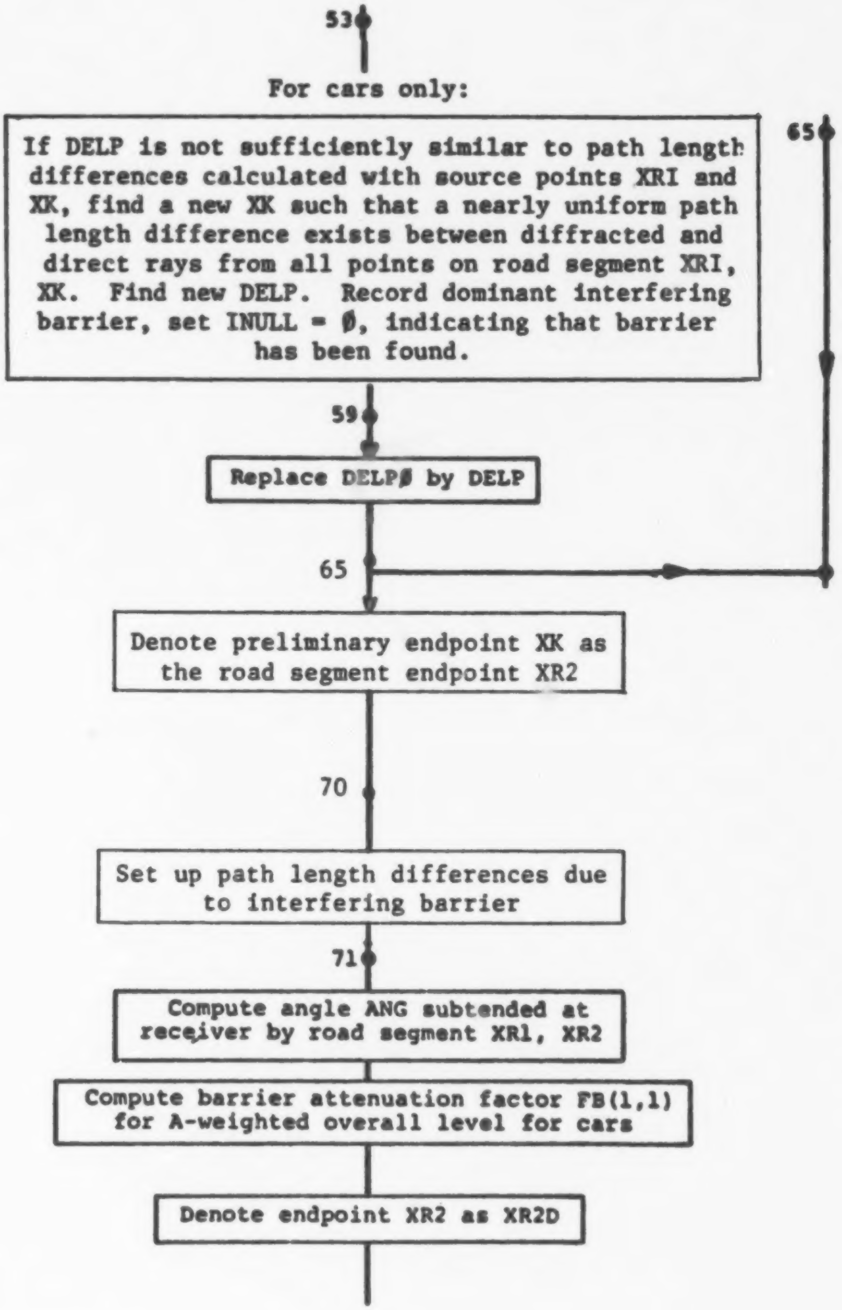
53
For cars only:
If DELP is not sufficiently similar to path length differences calculated with source points XRI and XK, find a new XK such that a nearly uniform path length difference exists between diffracted and direct rays from all points on road segment XRI, XK. Find new DELP. Record dominant interfering barrier, set INULL = 0, indicating that barrier has been found.
65
59
Replace DELP0 by DELP
65
Denote preliminary endpoint XK as the road segment endpoint XR2
70
Set up path length differences due to interfering barrier
71
Compute angle ANG subtended at receiver by road segment XR1, XR2
Compute barrier attenuation factor FB(1,1) for A-weighted overall level for cars
Denote endpoint XR2 as XR2D

FIGURE 3-8. (Concluded)

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GEOMRY bases the selection of signficant barrier diffraction using the source height adjustment specified for automobiles and light trucks. Once the subdivision of the roadway has proceeded so that the criteria os Equation (A-21) has been satisfied, the path length difference for each vehicle type is computed. These values are compared with the maximum values of path length difference stored in array DELPO to ensure that the maximum value for the path length difference is retained. Hence, barrier attenuation is calculated by vehicle type using the maximum value of the path length difference encountered between the roadway subsegment and the receiver. This procedure allows consideration of only the most effective barrier in multi-barrier configurations (See Section A.6, Appendix A). The reader should be aware that the maximum path length difference may no correspond to the highest barrier but depends upon source locations, barrier evaluation, and receiver location.

Figure 3-9 presents the flow diagram for the preliminary selection of reflectors in GEOMRY. By the introduction of an image receiver location, the reflection problem becomes similar to the diffraction problem. A reflector in the path from the road segment to an image receiver is effective whenever a barrier in the path from the road segment to a receiver strongly diffracts the sound.

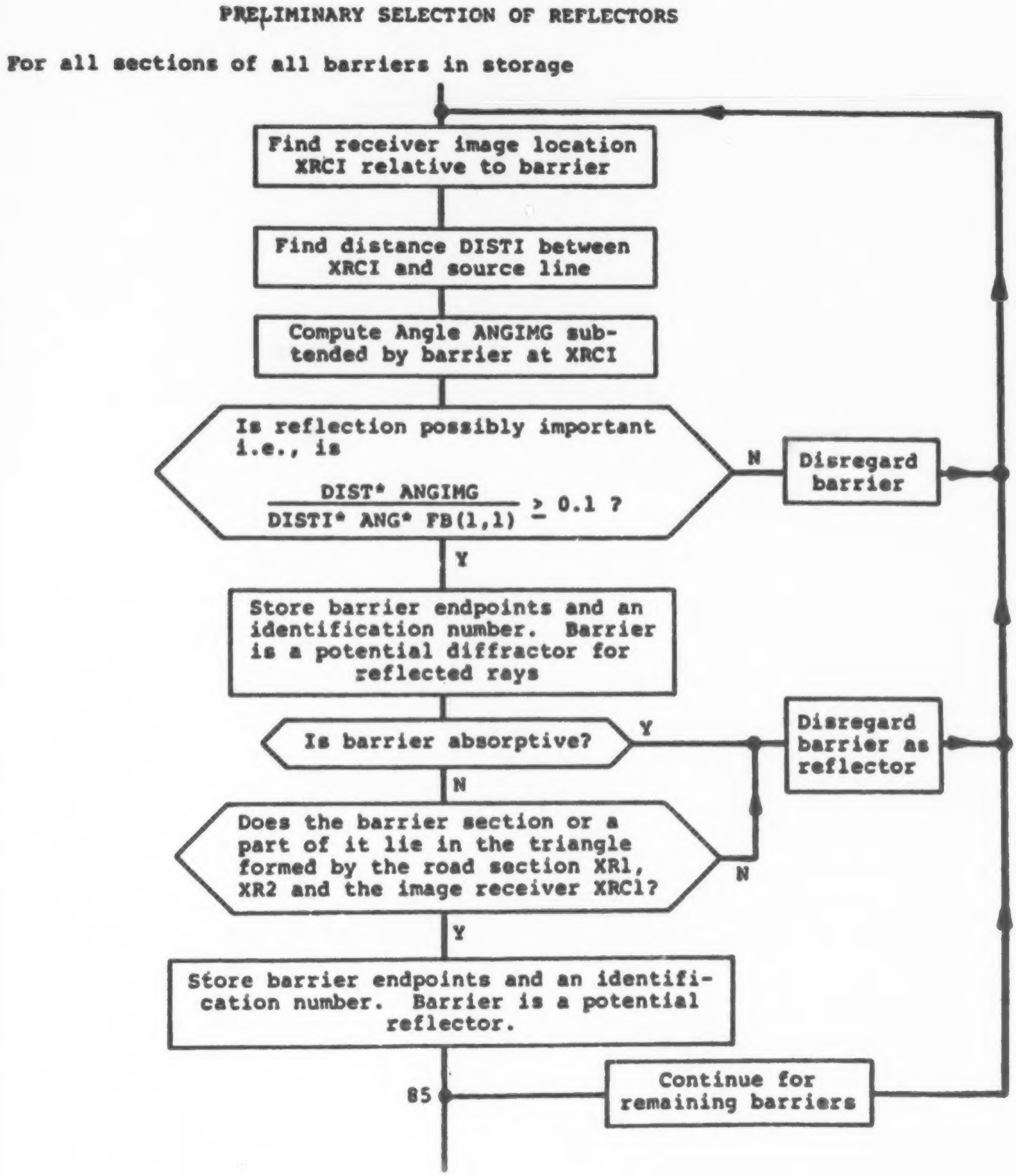
PRELIMINARY SELECTION OF REFLECTORS
For all sections of all barriers in storage
Find receiver image location XRCI relative to barrier
Find distance DISTI between XRCI and source line
Compute Angle ANGIMG subtended by barrier at XRCI
Is reflection possibly important i.e., is DIST* ANGIMG / DISTI* ANG* FB(1,1) ≥ 0.1 ?
N
Disregard barrier
Y
Store barrier endpoints and an identification number. Barrier is a potential diffractor for reflected rays
Is barrier absorptive?
Y
Disregard barrier as reflector
N
Does the barrier section or a part of it lie in the triangle formed by the road section XR1, XR2 and the image receiver XRC1?
N
Y
Store barrier endpoints and an identification number. Barrier is a potential reflector.
85
Continue for remaining barriers

FIGURE 3-9 SUBROUTINE GEOMRY: FLOW DIAGRAM FOR THE PRELIMINARY SELECTION OF REFLECTORS

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Also, the intensity of the direct (or diffracted) sound from the road segment considered is compared to the potential maximum contribution of each reflection. This check assures that only essential reflectors are considered. Since a reflector might not be high enough or reflections might be strongly attenuated by diffraction at additional barriers in the ray path, the reflectors found at this stage are considered "potential" reflectors.

During the preliminary selection of reflectors GEOMRY also conducts the preliminary selection of barriers which can possibly diffract the reflected sound. The check performed is based on the length and orientation of a barrier section and on the distance from the image receiver relative to the respective parameters of the road section and the receiver considered.

Figure 3-10 is the flow diagram for the block of code in GEOMRY that considers barrier elevation as related to potential reflection of sound. If the height difference above the reflector of a sound ray from the nearest point on the road segment leads to the acceptance or rejection of the reflector, no further check is made for other source points on the road segment.

Since diffraction of the reflected ray is not yet checked, a reflection is still called a potential one and the end point of the road segment is preliminary. As the final step in the reflector problem, GEOMRY considers possible diffraction both before reflection and after reflection.

Figure 3-11 presents the flow diagram for consideration of diffraction before reflection. Checks for barriers in the area defined by projections of the four points XR1, XR2, XRB3, and XRB4 into the x-y plane are made by considering first the triangle containing image rays and then the triangle formed by the road segment and the image receiver.

If a barrier is found to be high enough for possible diffraction, the reflector is checked again to determine whether or not it is

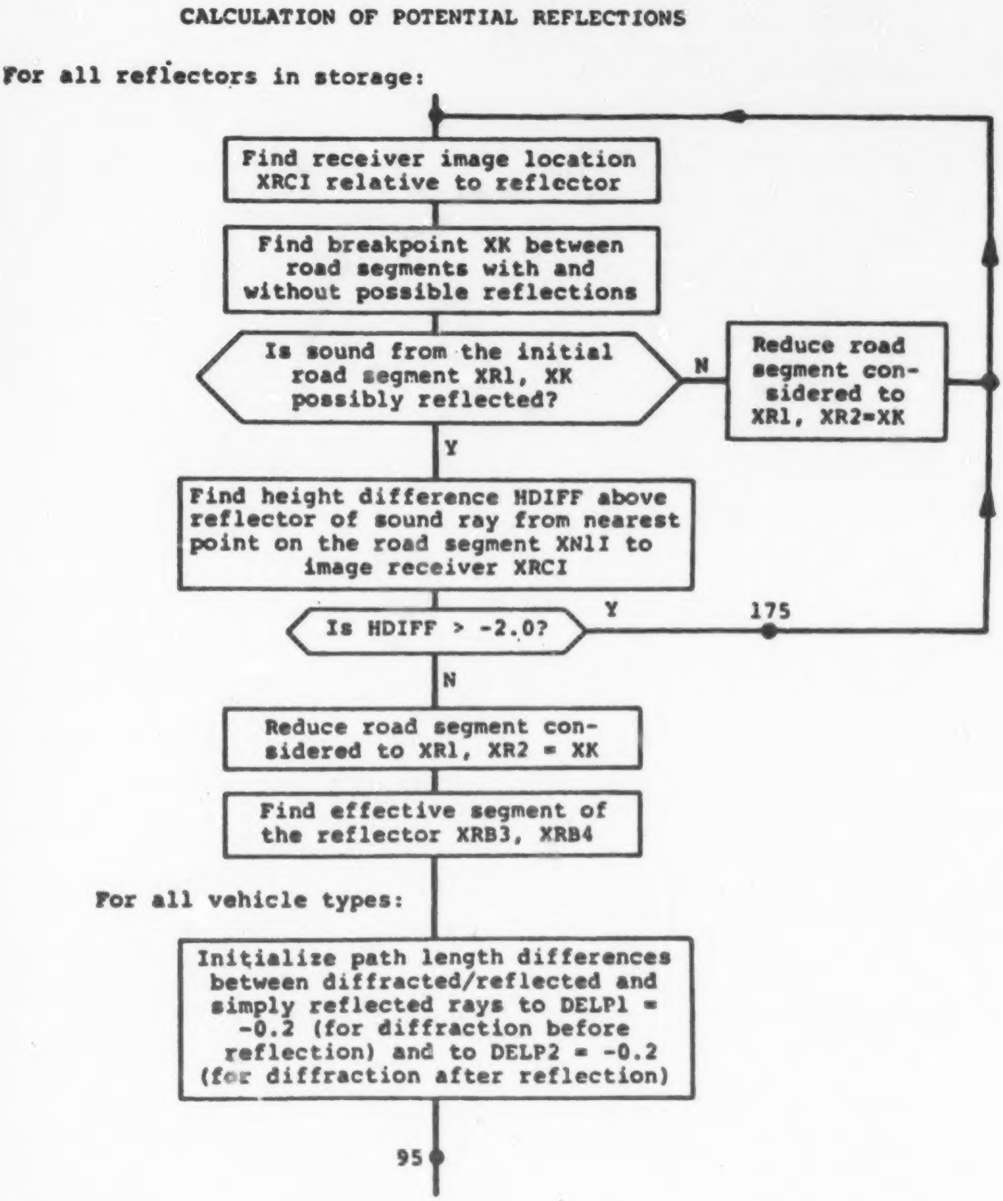
CALCULATION OF POTENTIAL REFLECTIONS
For all reflectors in storage:
Find receiver image location XRCI relative to reflector
Find breakpoint XK between road segments with and without possible reflections
Is sound from the initial road segment XR1, XK possibly reflected?
N
Reduce road segment considered to XR1, XR2=XK
Y
Find height difference HDIFF above reflector of sound ray from nearest point on the road segment XN1I to image receiver XRCI
Is HDIFF > -2.0?
Y
175
N
Reduce road segment considered to XR1, XR2 = XK
Find effective segment of the reflector XRB3, XRB4
For all vehicle types:
Initialize path length differences between diffracted/reflected and simply reflected rays to DELP1 = -0.2 (for diffraction before reflection) and to DELP2 = -0.2 (for diffraction after reflection)
95

FIGURE 3-10 SUBROUTINE GEOMRY: FLOW DIAGRAM FOR CALCULATION OF POTENTIAL REFLECTIONS

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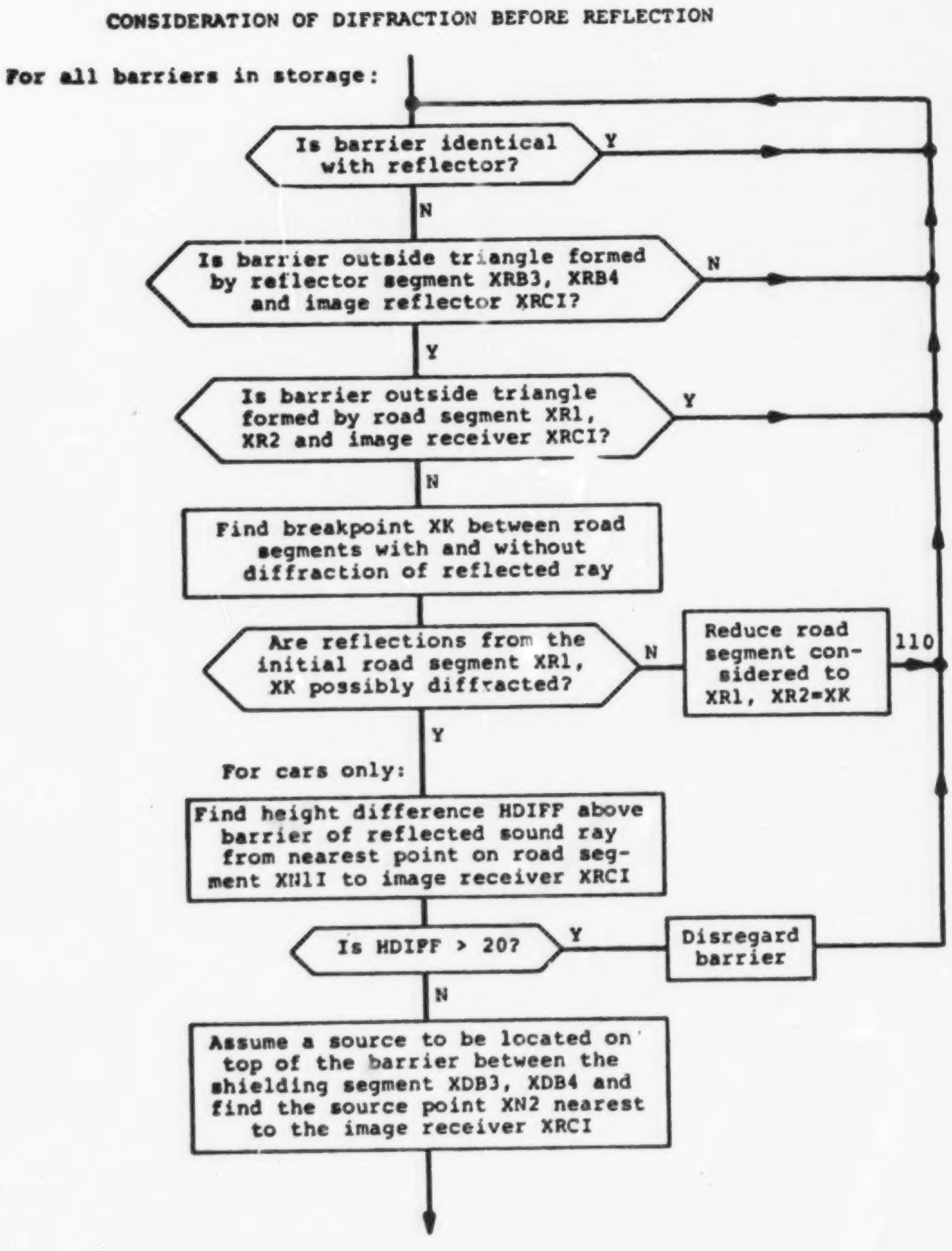
CONSIDERATION OF DIFFRACTION BEFORE REFLECTION
For all barriers in storage:
Is barrier identical with reflector?
Y
N
Is barrier outside triangle formed by reflector segment XRB3, XRB4 and image reflector XRCI?
N
Y
Is barrier outside triangle formed by road segment XR1, XR2 and image receiver XRCI?
Y
N
Find breakpoint XK between road segments with and without diffraction of reflected ray
Are reflections from the initial road segment XR1, XK possibly diffracted?
N
Reduce road segment considered to XR1, XR2=XK
110
Y
For cars only:
Find height difference HDIFF above barrier of reflected sound ray from nearest point on road segment XN1I to image receiver XRCI
Is HDIFF > 20?
Y
Disregard barrier
N
Assume a source to be located on top of the barrier between the shielding segment XDB3, XDB4 and find the source point XN2 nearest to the image receiver XRCI

FIGURE 3-11 SUBROUTINE GEOMRY: FLOW DIAGRAM FOR CONSIDERATION OF DIFFRACTION BEFORE REFLECTION

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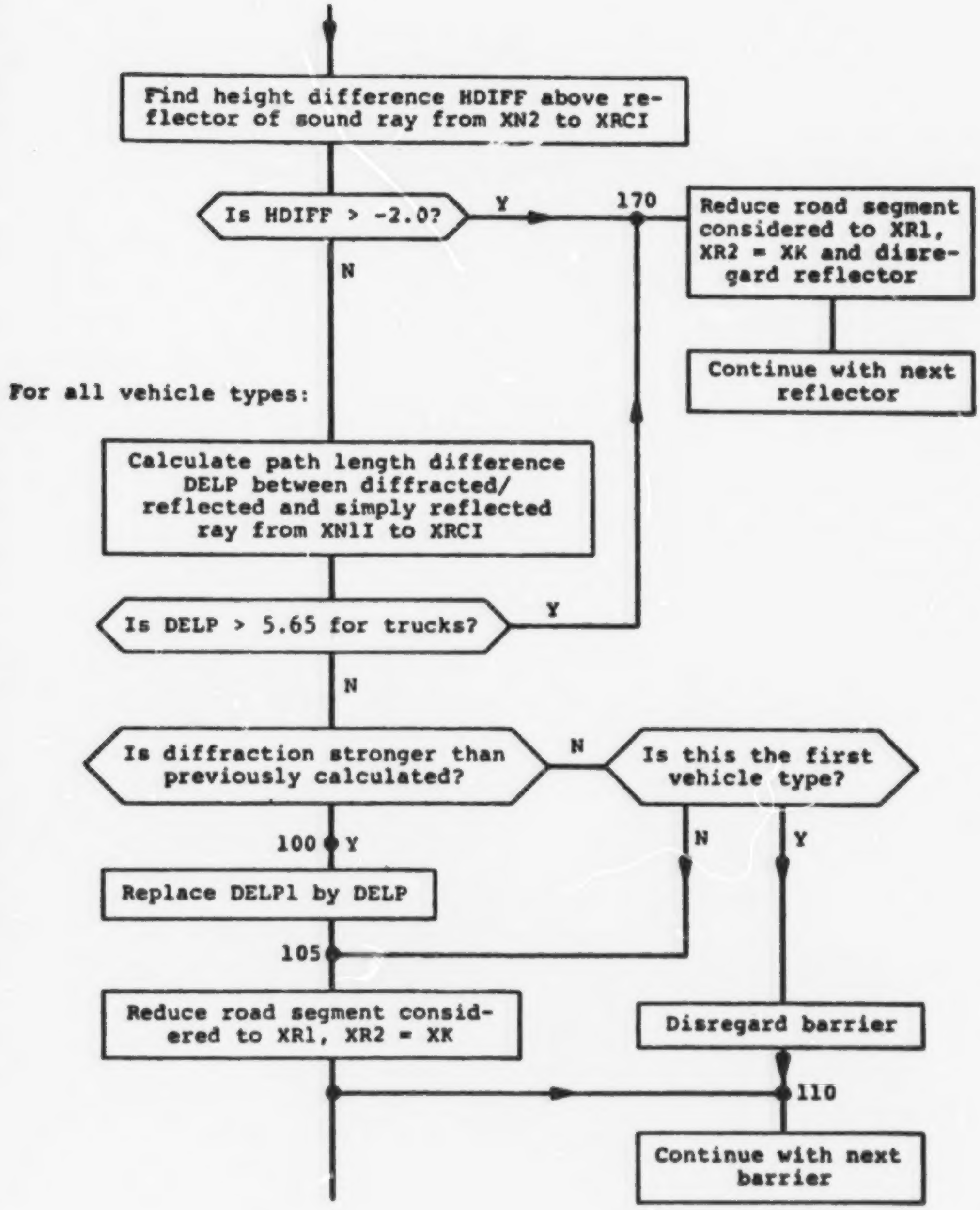
Find height difference HDIFF above reflector of sound ray from XN2 to XRCI
Is HDIFF > -2.0?
Y
170
N
Reduce road segment considered to XR1, XR2 = XK and disregard reflector
Continue with next reflector
For all vehicle types:
Calculate path length difference DELP between diffracted/reflected and simply reflected ray from XN1I to XRCI
Is DELP > 5.65 for trucks?
Y
N
Is diffraction stronger than previously calculated?
N
Is this the first vehicle type?
100
Y
N
Y
Replace DELP1 by DELP
105
Reduce road segment considered to XR1, XR2 = XK
Disregard barrier
110
Continue with next barrier

FIGURE 3-11 (Concluded)

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high enough to reflect the diffracted rays (which now come from an effective source that might by considerably higher than the roadway).

Calculation of the path length difference between diffracted and direct rays from only the near point of the road segment implies that the diffraction of sound rays from other source points is about the same.

Very strongly diffracted reflections are neglected. The decision is made on the basis of the diffraction of sound from trucks, since rays from cars are even more strongly diffracted.

Figure 3-12 presents the flow diagram for the consideration of diffraction after reflection. Checks are made for diffracting barriers in the triangle defined by projections of the reflector segment (XRB3, XRB4) and the receiver XRC onto the x-y plane.

After a barrier has been found which is high enough for possible diffraction, the reflector is checked to determine whether or not it is high enough to reflect sound towards the top line of the diffracting barrier, which might be considerably higher than the receiver.

Calculation of the path length difference implies simplifying assumptions similar to those for the problem of diffraction before reflection.

Reflections are neglected in the case of diffraction before and after reflection and in the case of very strong diffraction after reflection.

Figure 3-13 presents the flow diagram representing the block of code in GEOMRY that performs the final computations and accumulation of sound intensities at the receiver. These calculations consider barrier diffraction, reflections (gain of direct sound), atmospheric absorption, and ground absorption. The calculations are directly related to the expression given in Appendix A, Equation (A-9) for the acoustic intensity. For the octave band center frequency of 500 Hz, the cumulant, κ_2^*, of the acoustic intensity is calculated (See Equation A-11) and accumulated.

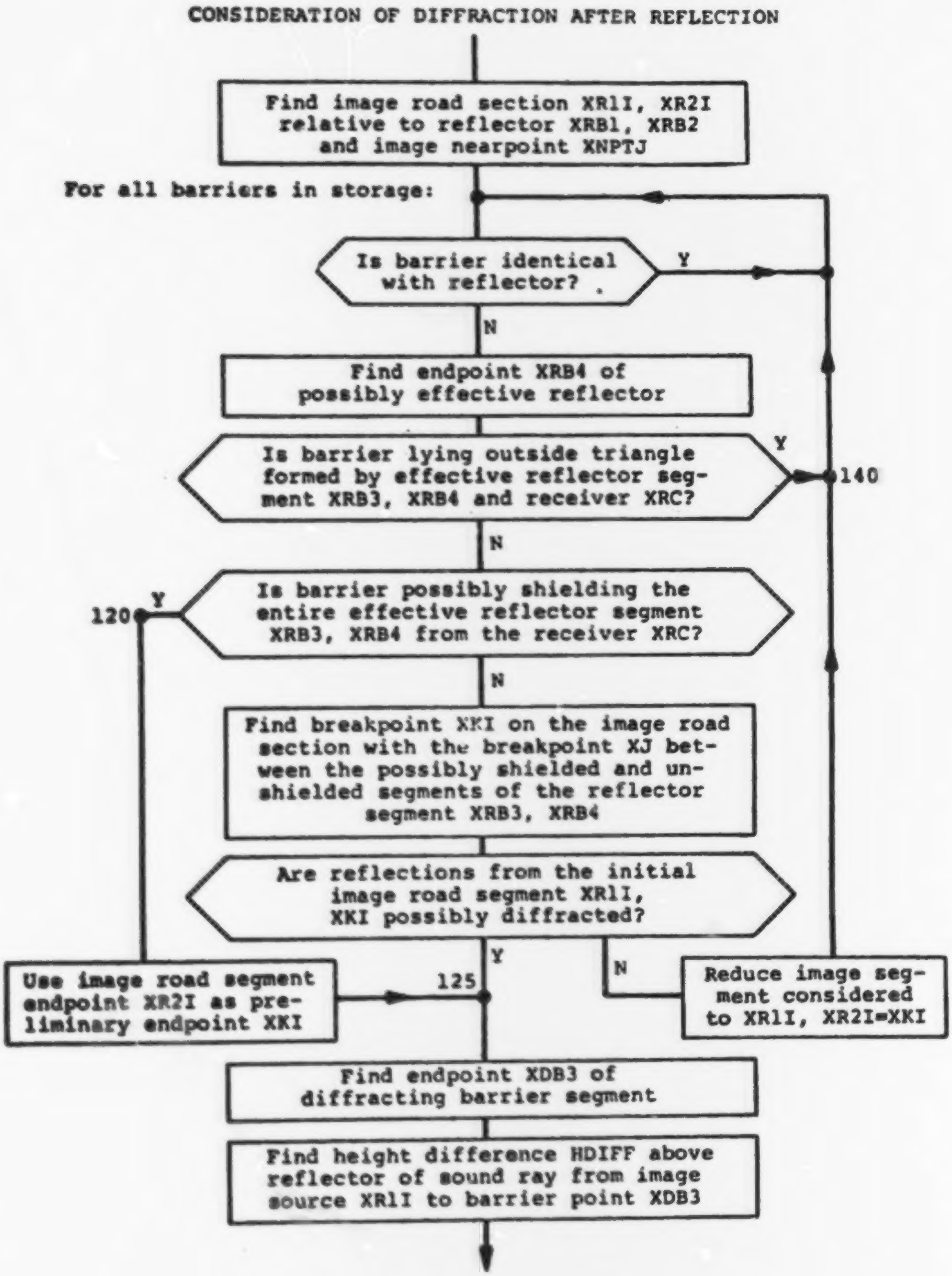
CONSIDERATION OF DIFFRACTION AFTER REFLECTION
Find image road section XR1I, XR2I relative to reflector XRB1, XRB2 and image nearpoint XNPTJ
For all barriers in storage:
Is barrier identical with reflector?
Y
N
Find endpoint XRB4 of possibly effective reflector
Is barrier lying outside triangle formed by effective reflector segment XRB3, XRB4 and receiver XRC?
Y
140
N
120
Y
Is barrier possibly shielding the entire effective reflector segment XRB3, XRB4 from the receiver XRC?
N
Find breakpoint XKI on the image road section with the breakpoint XJ between the possibly shielded and unshielded segments of the reflector segment XRB3, XRB4
Are reflections from the initial image road segment XR1I, XKI possibly diffracted?
Y
N
Use image road segment endpoint XR2I as preliminary endpoint XKI
125
Reduce image segment considered to XR1I, XR2I=XKI
Find endpoint XDB3 of diffracting barrier segment
Find height difference HDIFF above reflector of sound ray from image source XR1I to barrier point XDB3

FIGURE 3-12 SUBROUTINE GEOMRY: FLOW DIAGRAM FOR CONSIDERATION OF DIFFRACTION AFTER REFLECTION

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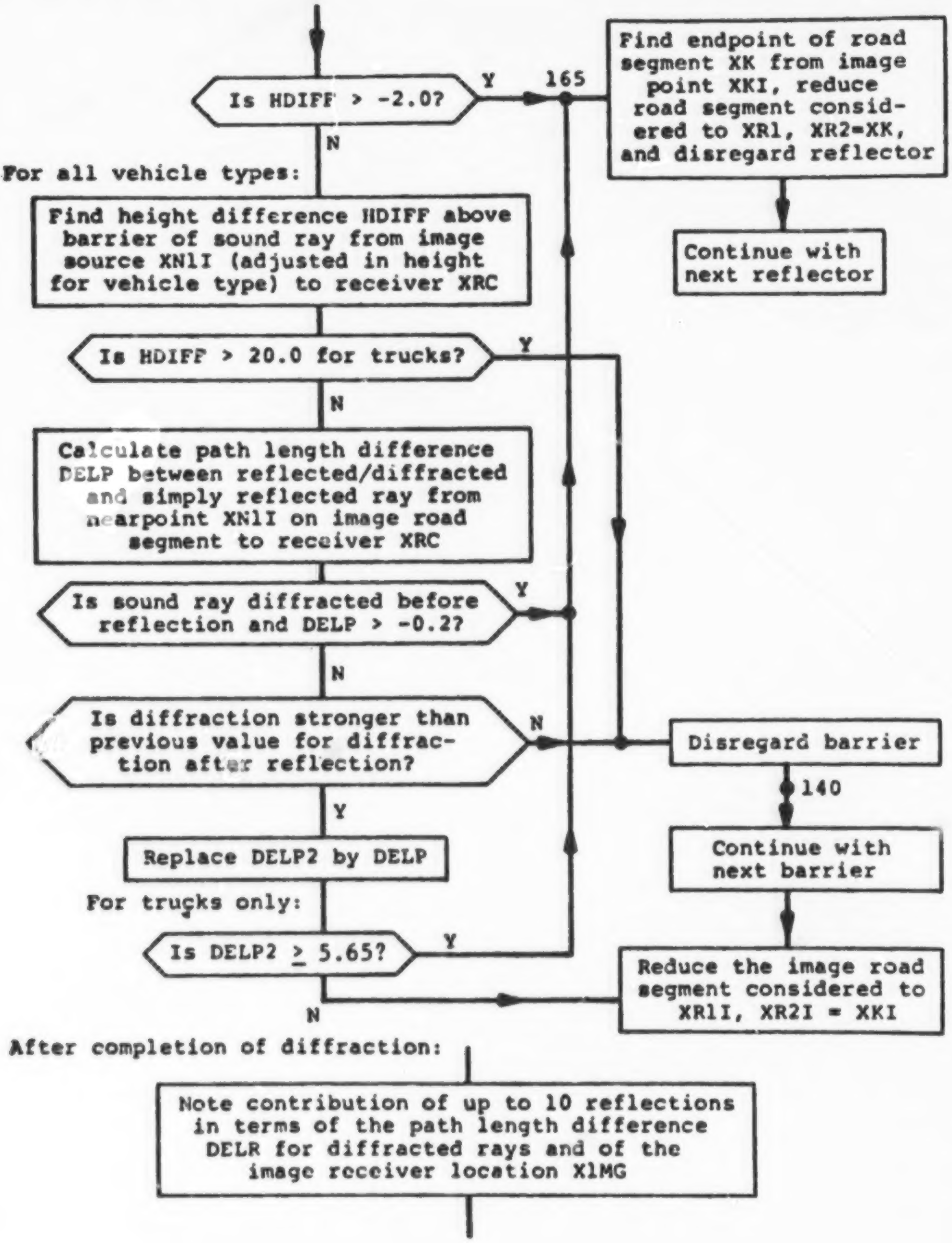
Is HDIFF > -2.0?
Y
165
N
Find endpoint of road segment XK from image point XKI, reduce road segment considered to XR1, XR2=XK, and disregard reflector
Continue with next reflector
For all vehicle types:
Find height difference HDIFF above barrier of sound ray from image source XN1I (adjusted in height for vehicle type) to receiver XRC
Is HDIFF > 20.0 for trucks?
Y
N
Calculate path length difference DELP between reflected/diffracted and simply reflected ray from nearpoint XN1I on image road segment to receiver XRC
Is sound ray diffracted before reflection and DELP > -0.2?
Y
N
Is diffraction stronger than previous value for diffraction after reflection?
N
Disregard barrier
140
Continue with next barrier
Y
Replace DELP2 by DELP
For trucks only:
Is DELP2 ≥ 5.65?
Y
N
Reduce the image road segment considered to XR1I, XR2I = XKI
After completion of diffraction:
Note contribution of up to 10 reflections in terms of the path length difference DELR for diffracted rays and of the image receiver location XIMG

FIGURE 3-12 (Concluded)

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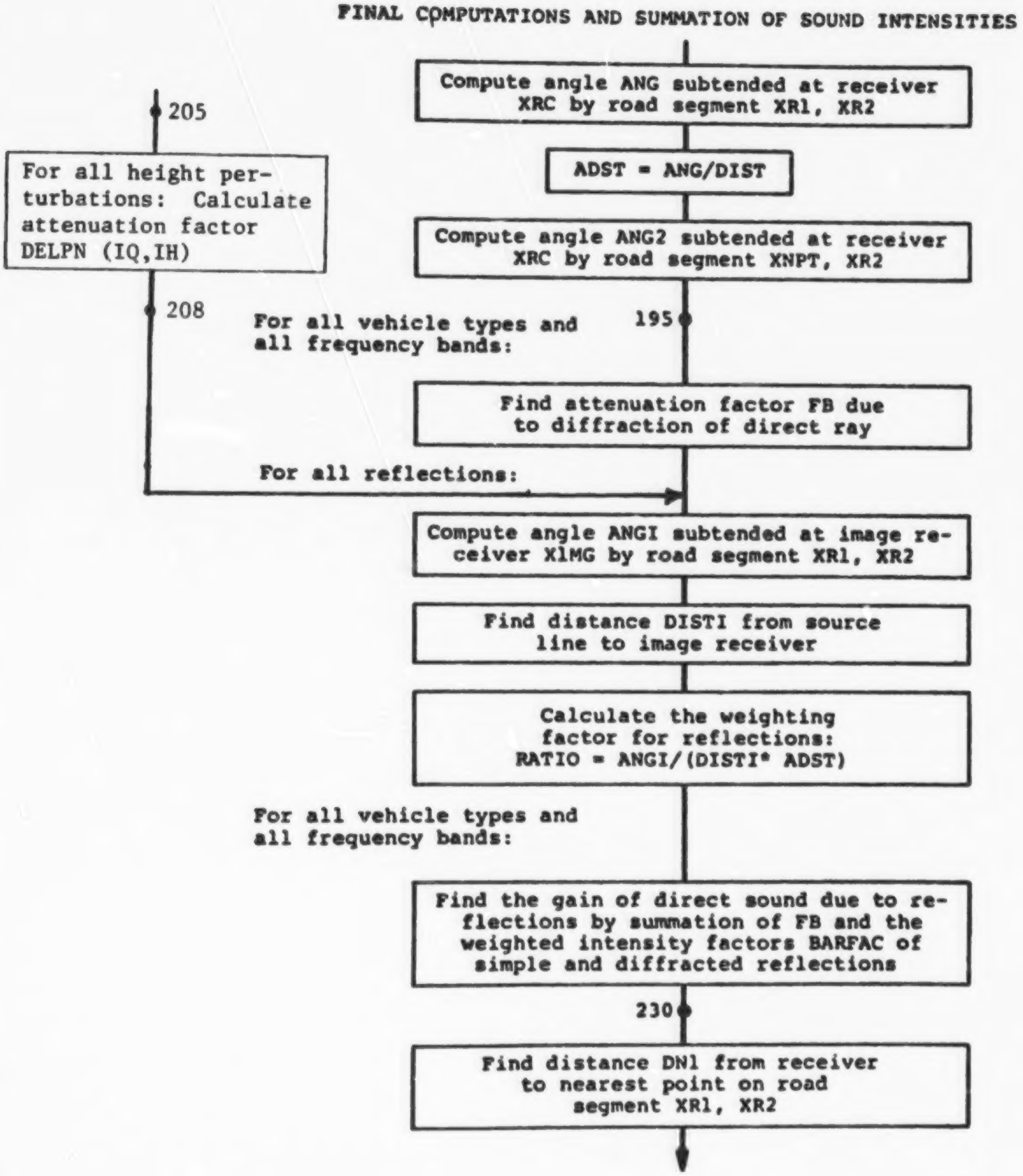
FINAL COMPUTATIONS AND SUMMATION OF SOUND INTENSITIES
Compute angle ANG subtended at receiver XRC by road segment XR1, XR2
ADST = ANG/DIST
Compute angle ANG2 subtended at receiver XRC by road segment XNPT, XR2
205
For all height perturbations: Calculate attenuation factor DELPN (IQ,IH)
208
For all vehicle types and all frequency bands:
195
Find attenuation factor FB due to diffraction of direct ray
For all reflections:
Compute angle ANGI subtended at image receiver XIMG by road segment XR1, XR2
Find distance DISTI from source line to image receiver
Calculate the weighting factor for reflections: RATIO = ANGI/(DISTI* ADST)
For all vehicle types and all frequency bands:
Find the gain of direct sound due to reflections by summation of FB and the weighted intensity factors BARFAC of simple and diffracted reflections
230
Find distance DN1 from receiver to nearest point on road segment XR1, XR2

FIGURE 3-13 ·SUBROUTINE GEOMRY: FLOW DIAGRAM FOR FINAL CALCULATION AND SUMMATION OF SOUND INTENSITIES

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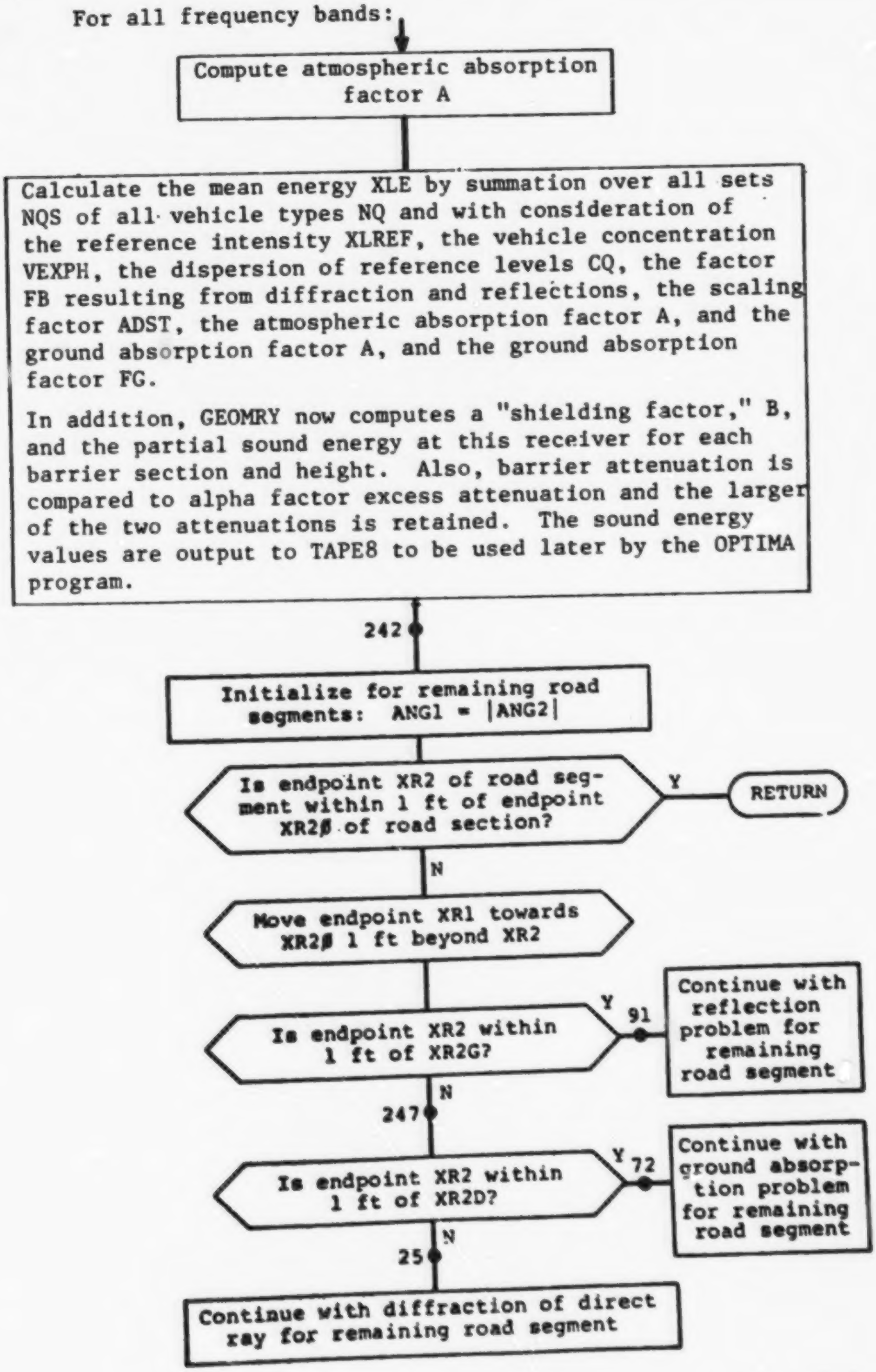

For all frequency bands:

Compute atmospheric absorption factor A

Calculate the mean energy XLE by summation over all sets NQS of all vehicle types NQ and with consideration of the reference intensity XLREF, the vehicle concentration VEXPH, the dispersion of reference levels CQ, the factor FB resulting from diffraction and reflections, the scaling factor ADST, the atmospheric absorption factor A, and the ground absorption factor A, and the ground absorption factor FG.

In addition, GEOMRY now computes a "shielding factor," B, and the partial sound energy at this receiver for each barrier section and height. Also, barrier attenuation is compared to alpha factor excess attenuation and the larger of the two attenuations is retained. The sound energy values are output to TAPE8 to be used later by the OPTIMA program.

Initialize for remaining road segments: ANG1 = |ANG2|

Is endpoint XR2 of road segment within 1 ft of endpoint XR20 of road section?

Move endpoint XR1 towards XR20 1 ft beyond XR2

Is endpoint XR2 within 1 ft of XR2G?

Continue with reflection problem for remaining road segment

Is endpoint XR2 within 1 ft of XR2D?

Continue with ground absorption problem for remaining road segment

Continue with diffraction of direct ray for remaining road segment

FIGURE 3-13 (Concluded)

BEST DOCUMENT AVAILABLE

After the calculation and accumulation of acoustic intensity, GEOMRY checks to see if the subsegment end point XR2 is within a prescribed distance to the end points of the subsegments defining the segment end point XR20, or the subsegment end point XR2G corresponding to a ground strip, or a subsegment end point XR2D corresponding to a diffraction. GEOMRY branches internally to continue to roadway segment analysis until the point XR2 is within 1 foot of the segment end point XR20. When this criteria is satisfied, GEOMRY returns control to the MAIN program.

In addition to the previously described calculations, GEOMRY (in STAMINA 2.0 version) will compute path length differences for each of the barrier height perturbations, as it is performing the standard barrier computations. As it performs the accumulations of acoustic intensity for each receiver, the sums of sound level antilogs are also computed for each height perturbation--for all barrier sections and then output to a secondary storage device (TAPE8) to be used later by the program OPTIMA.

GEOMRY also compares the total excess attenuation provided by a barrier to that provided by an alpha factor for each vehicle type--roadway sub-segment--receiver combination, and saves only the larger of the two excess attenuation values.

SUBPROGRAMS REQUIRED

See Figure 2-1.

VARIABLES

Due to the lengthy and complex nature of subroutine GEOMRY, variables are listed in alphabetical order.

A	**Atmospheric attenuation factor, ground absorption parameter**
ADST	**ANG/DIST**
ANG	**Angle subtended at receiver by road segment**
ANG1	**Angle α_1 in Fig. A-1**
ANG2	**Angle α_2 in Fig. A-1**
ANGI	**Angle subtended at image receiver by road segment**

AMGIMG	Angle subtended at image receiver by barrier section
B1	End point of barrier section
B	Shielding factor for roadway and receiver
BARRT	Temporary variable used in comparison of barrier vs. alpha factor excess attenuation
BLAST(IBAR)	Associated with type of last barrier section
BX	x-coordinate of barrier point
BY	y-coordinate of barrier point
BZ	z-coordinate of barrier point
CAP2	Statistical variable for computation
CQ	Factor accounting for standard deviation of reference level
DELM	Mean path length difference
DELP	Path length difference
DELPO	Maximum path length difference for diffraction of direct ray
DELP1	Maximum path length difference for diffraction before reflection
DELP2	Maximum path length difference for diffraction after reflection
DELPA	Path length difference for diffraction of direct ray
DELPN(NQ,NHP)	The path length differences, as function of vehicle type and height perturbation
DELR	Path length difference for reflected ray
DELTA	Distance along the roadway
DIST	Distance from the receiver to the source line
DISTI	Distance from the image receiver to the source line
DISTJ	Distance from the image receiver to the diffracting barrier
DN1	Distance from the receiver to the nearest point of the road segment

DN1I	Distance from the image receiver to the nearest point of the road segment
DN2	Distance from the image receiver to the nearest point of the diffracting barrier
DR1	Distance from the receiver to the initial point of the road segment
DRK	Distance from the receiver to the preliminary end point of the road segment
DZ(NB)	Area height increment as function of barrier
FB	Attenuation factor accounting for diffraction and reflections
FCTR	Weighting factor for reflections
FG	Ground attenuation factor
GAM	Alpha factor
HDIFA	Height of ray from source point XR1 to receiver XRC above barrier
HDIFF	Height of ray above barrier, reflector
I	Index
IBAR	Barrier number
IDXR	Number of reflections
IERR	Error index
IGOO(MR,N-1)	Grade designation for particular roadway section
IH	Index
IF	Index for frequency bands
II	Index
IK	Frequency band number
INDEX	Storage index for variable XLREF, computed by roadway number and vehicle type
INTEG	Key variable to indicate whether alpha factors being used in computation
INULL	Indicating whether or not reflective barrier found

IP	Frequency band number
IQ	Index for vehicle types
IR	Alphanumeric "R"
IREFL	Flag indicating whether or not reflection calculations are to be done
ISAV	Temporary storage of reflective barrier found
ISEG	Barrier section number
IST(NB,NO)	Roadway numbers associated with structure barriers
J	Index
JQ	Index
KAR	Alphanumeric indicator for type of barrier
KBAR	Total number of barrier sections; index for barriers
KBAR1	Reflector number in storage
KBAR2	Diffractor number in storage
KBCODE	Indicator for relative location of barrier
KCD	Indicator for relative location of barrier
KDIFF	Barrier number in storage
KGCODE	Indicator for relative location of ground strip
KIMG	Reflection number
KNUMB	Total number of relevant barrier sections
KREF	Reflector number stored
KRDNUM	Total number of barrier sections relevant to reflection
KRFDF	Barrier number stored
KRNUM	Total number of relevant reflector sections
KTRIG	Indicator for intersection of barrier
LOC	Indicator for relative location of barrier
MDIFF	Indicator for diffraction before reflection
MODD	Indicator for diffraction of direct ray

MR	Roadway number
MRC	Receiver number
N	Cumulant numbers
NB	Number of barriers
NBSEC	Number of barrier sections
NBSM1	Number of sections for one barrier
NDIFF	Number of barriers stored
NF	Number of frequency bands
NHP	Number of height perturbations
NIMG	Number of reflections
NLIM	Number of points defining one barrier
NP	Number of plus and minus perturbations per barrier
NQ	Number of vehicle types
NQQ	Number of groups within one vehicle type
NQS	Vector notation for number of vehicle groups
NR	Number of roadways
NREF	Number of reflectors stored
NRFDF	Number of barriers stored
NSTB	Maximum number of structure barriers per roadway
PP	Frequency band number
R1	End point of potential reflector
RATIO	Weighting factor for reflected rays
RB1	End point of barrier in path of reflected ray
RDIN	Vector notation for initialization parameters
RNULL(MRC)	The "left over" sound energy (in level antilog) that reaches each receiver without passing over any barrier sections
SS	Alpha constant "s"
T1	Temporary variable
T2	Temporary variable
T3	Temporary variable

TEM1	Temporary variables (similar to ADST) used in comparing effects of barrier vs. alpha factor excess attenuation
TEM2	
TEM1B	
TEM2B	
VEXPH	**Vehicles per foot**
XB1	**Initial point of barrier stored**
XB2	**End point of barrier stored**
XDB1	**Initial point of barrier stored**
XDB2	**End point of barrier stored**
XDB3	**Initial point of effective barrier segment**
XDB4	**End point of effective barrier segment**
XIMG	**Vector of image receivers for all reflections**
XJ	Preliminary end point of effective reflector segment
XK	Preliminary end point of road segment
XKI	Preliminary end point of image road segment
XLE	Mean intensity
XLREF	Vector notation for reference intensities
XN1	Point on road segment nearest to receiver
XN1I	Point on road segment nearest to image receiver; point on image road segment nearest receiver
XN2	Point on barrier segment nearest to image receiver
XNPT	Point on source line nearest to receiver
XNPTI	Point on source line nearest to image receiver
XNPTJ	Point on image source line nearest receiver
XR	X-coordinate of receiver
XR1	Initial point of road segment
XR10	Initial point of road section

XR1I	**Initial point of image road segment**
XR2	**End point of road segment**
XR20	**End point of road section**
XR2D	**End point of road segment with constant attenuation by diffraction**
XR2G	**End point of road segment with constant attenuation by ground absorption**
XR2I	**End point of image road segment**
XRB1	**Initial point of reflector stored**
XRB2	**End point of reflector stored**
XRB3	**Initial point of effective reflector segment**
XRB4	**End point of effective reflector segment**
XRC	Receiver point
XRCI	Image receiver point
XSV(3,IQ)	Temporary array to store x, y, z coordinate positions during barrier computations
XTA	Temporary variable for XLREF intensities
YR	Y-coordinate of receiver
ZN10	Z-coordinate of XN1 or XN1I
ZO(NB,NBSEC)	Barrier "ground height" as a function of barrier end points and barrier section number
ZR	Z-coordinate of receiver
ZS	Height adjustment for vehicles

NOTE: Variables BGS,BGT,DL,HGA,IDUM,IGRA,IKIN,KGA,KGCODE,NG,TA1,XG1,XG2, XG3,XG4,XXG1,YYG1,ZZG1 refer to absorptive ground strips which are not used in this version of STAMINA.

RESTRICTIONS

Due to the complex nature of subroutine GEOMRY, the user should use caution in attempting modifications. Changes in the direct calculation schemes related to the acoustic models assumed are found in the following lines of code:

Calculation of Barrier Attenuation
Calculation of Reflection Gain
Calculation of Normalized Mean Intensity and Dispersion of Mean Intensity
Calculation of Atmospheric Absorption

Note: If the user desires to modify the barrier model described in this manual, he is warned to check subroutine GEOMRY thoroughly as several important criteria required for decisions concerning the accumulation of uniform acoustic intensity at a receiver are affected. Similarly, the user should not attempt to blindly alter the code for dimensions in metric units without appropriate modification of GEOMRY and other subprograms.

ACCURACY

Dependent upon the acoustic models utilized in the problem formulation.

SIZE: 54466

REFERENCES

See Appendix A of the User's Manual.

3.34 FUNCTION FNC1(X)

PURPOSE: To calculate $\cos^{\alpha}(x)$ for use in computing the L_{eq} by integration over the roadway segment.

SUBPROGRAM USED: None

VARIABLES:
X - argument of cosine
XGAM - same as α
FNC1 - $\cos^{\alpha}(x)$

RESTRICTIONS: $\alpha \leq -1$

ACCURACY: not applicable

SIZE: 386

REFERENCES: Appendix A

3.35 FUNCTION FNC2(X)

PURPOSE: To calculate $\cos^{2(1+\alpha)}(x)$ for use in computing SIGMA

SUBPROGRAM USED: None

VARIABLES: X - argument of cosine

XGAM - same as α

FNC2 - $\cos^{2(1+\alpha)}(x)$

RESTRICTIONS: $\alpha \geq -1$

ACCURACY: not applicable

SIZE: 430

REFERENCES: Appendix A

3.36 SUBROUTINE DQATR (XL, XU, EPS, NDIM, FCT, Y, IER, AUX)

PURPOSE: To compute $\int_{XL}^{XU}$ FCT(X)dx by Romberg's method.

SUBPROGRAMS USED: External function FCT(X)

VARIABLES:

XL - lower bound of the interval.

XU - upper bound of the interval.

EPS - upper bound of the absolute error in single precision.

NDIM - dimension of the auxiliary storage array AUX NDIM-1 is the maximum number of bisections of the interval (XL, XU).

FCT - name of external double precision function subprogram used.

Y - resulting approximation for the integral.

IER - resulting error parameter.

RESTRICTIONS:

IER = 0 - it was possible to reach the required accuracy.

IER = 1 - it was impossible to reach the required accuracy because of rounding error.

IER = 2 - it was impossible to reach accuracy because NDIM is less than 5, or the required accuracy could not be reached within NDIM-1 steps. NDIM should be increased.

ACCURACY: Error within EPS as specified.

SIZE: 1276

REFERENCES: Anon.: "System 1360 Scientific Subroutine Package (360A-CM-03X), Version II, Programmer's Manual," H20-0205-1 (2nd Edition), International Business Machines Corporation, 1967.

3.37 FUNCTION GRADE (DR1,DR2)

PURPOSE:	To compute the grade correction to the sound level of type 2 vehicles (heavy trucks) on a given roadway segment.
SUBPROGRAM USED:	None
VARIABLES:	DR1 - xyz - coordinates of endpoint 1 of roadway segment DR2 - xyz - coordinates of endpoint 2 of roadway segment X - grade from endpoint 1 to endpoint 2 Y - grade correction of the segment GRADE - sound intensity level of grade correction i.e., GRADE = $10^{Y/10}$
RESTRICTIONS:	none
ACCURACY:	not applicable
SIZE:	630
REFERENCES:	The grade correction is a linear interpolation of the data given in Gorden, C. G., et. al.: "Highway Noise, A Design Guide for Prediction and Control," Highway Research Board, National Academy of Sciences, Report NCH-RP-174, 1976.

3.38 SUBROUTINE BARPRP(NB,IP)

PURPOSE: This subroutine computes barrier section lengths (SBL) from barrier coordinates (BX,BY,BZ); and barrier height increments from barrier height data (BZ and Z0). The barrier section lengths are calculated from the barrier definitions previously input. As the length is computed, the barrier height increments array (DELZ) is set to the barrier height increment (DZ) — except for DELZ(NSEC,1) — which is calculated from the difference average of the barrier section height coordinate (BZ) and zero height (Z0), minus the input barrier height increment (DZ). Once the increments are computed, they can be written to the file TAPE 8 for later use in program OPTIMA.

SUBPROGRAMS USED: AMAG(XB1,XBZ), REPLCE(XB2,XB1), OUTP1(NB,NBSM1).

VARIABLES: Input Parameters

BX(I,J),BY(I,Y),BZ(I,J) — Barrier section endpoint coordinates in x,y,z space.

DZ(I) — Constant height increment value for each barrier.

IP — Parameter used to control output to file TAPE 8. If nonzero, then barrier height information is written to TAPE 8.

NB — The total number of barriers in system.

MBSM1(I) — Array containing the number of sections per barrier. This variable is passed directly to subroutine OUTP1.

NP(I) — Number of plus and minus height increments per barrier.

Subprogram Parameters

DELZ(I,J) — Equivalenced to RP(I,J) — used to store the barrier height increment for each barrier section and height index.

NH — The total number of indices used for height increment arrays. It is computed as, NH = 2 * NP(I) + 1.

NSEC — Integer variable used to count barrier section number contiguously.

XB1(I),XBZ(I) — Set to barrier endpoint coordinates (BX,BY,BZ) and used to compute barrier lengths-stored in SBL.

Output Parameters

DELZ(I,J) — COMMON equivalenced to RP(I,J) — contains the barrier height increments per barrier section. (RP will be used after this subprogram is called.)

RESTRICTIONS: The subprogram BARPRP is used to compute barrier height increments needed by program OPTIMA. If the increments are input incorrectly or if an improper ZO is used, BARPRP will compute a nonpositive height increment and will issue an error message indicating barrier number (I) and section number (J). Aside from this, it is assumed that the numbers of barriers and sections are properly passed.

ACCURACY: Not applicable.

SIZE: 1230

REFERENCES: None.

3.39 SUBROUTINE CDELP(XSV,XRC,IBAR,NB,NQ)

PURPOSE: To compute the perturbed barrier heights – relative to a receiver height, and to compute path length difference for each perturbed height and vehicle type.

SUBPROGRAMS USED: NBSET(I,IA,N), AMAG(X1,X2), HEIGHT(X1,X2,X3,X4), DEL(X1,X2,X3,X4,H,D).

VARIABLES: Input Parameters

BX(I,J),BY(I,J),BZ(I,J),ZO(I,J) – x,y,z and zero height coordinates of barriers – defined per barrier number I and barrier section J.

DZ(I) – Barrier height increments per barrier I.

IBAR – Barrier section – on which computations are to be performed.

NB – Total number of barriers.

NBSM1(I) – Number of barrier sections per barrier I.

NP(I) – Number of plus and minus height increments per barrier.

NQ – Total number of vehicle types.

XRC(I) – Receiver coordinates x,y,z defined as I = 1,2,3, respectively.

XSV(I,J) — x,y,z coordinates (I) of a point on a barrier (defined by barrier number IBAR) per vehicle type J.

Subprogram Parameters

DN1 — Path length difference between point of interest XSV and receiver XRC.

HDIFF — Elevation difference between points XSV and receiver XRC.

IB — Number of barrier containing barrier section of interest.

JB — Barrier section number relative to IB.

JBAR — Temporary variable defining the contiguous barrier section number on input, and relative barrier section number on exit of subprogram NBSET.

NHP — Total number of barrier height indices.

XB1(I),XB2(I) — Used temporarily as coordinates of the endpoints of a barrier section.

XB1(3),XB2(3) — Contains the perturbed barrier heights.

DELPN(I,J) — The path length difference between point of interest XSV(K,J) and receiver XRC — for vehicle type I and height perturbation J (computed with respect to DN1 and HDIFF).

RESTRICTIONS: Dependent upon those of subprograms used. This routine assumes that the contiguous barrier section number IBAR is in proper form to locate barrier number and section number.

ACCURACY: Dependent on subprograms used.

SIZE: 1254

REFERENCES: None.

3.40 SUBROUTINE OUTP1(NB,NBSM1)

PURPOSE: To output all geometry information and barrier titles to file TAPE 8 – to be used later by program OPTIMA.

SUBPROGRAMS USED: NBSET(I,J,N).

VARIABLES:

Input Parameters

BT(I,K) – Barrier title (8 characters) for barrier number I and section K.

DELZ(I,L) – Barrier height increment of barrier I and perturbation index L.

NB – Total number of barriers.

NBSEC – Total number of barrier sections.

NBSM1(I) – Number of barrier sections per barrier I.

NP(I) – Number of plus and minus height increments per barrier I.

SBL(J) – Barrier section length per contiguous barrier section J.

Subprogram Parameters

IFL – Output file number.

II – Sequential barrier section number on input to subprogram NBSET – relative barrier section number on exit from NBSET.

JJ – Number of barrier containing the II barrier section.

JNP – Maximum index value for barrier height increments.

RP(I,L) – Equivalent to the DELZ – barrier height increments.

RESTRICTIONS:	This subprogram outputs barrier information in coded form to file TAPE 8 – to be saved for later use by program OPTIMA. Therefore, a physical device named TAPE 8 must be available during execution of STAMINA 2.0 – to be permanently saved for later use.
ACCURACY:	Not applicable.
SIZE:	860
REFERENCES:	None.

3.41 SUBROUTINE OUTP2(IRC,NRC,NB)

PURPOSE: To output receiver title and the partial sound energy values computed for each barrier section and height – given the receiver IRC.

SUBPROGRAMS USED: NBSET(I,J,N).

VARIABLES: Input Parameters

ALP(I) – Receiver title (8 characters)
IRC – Receiver number for which information is to be output.
NBSEC – Total number of barrier sections.
NBSM1(I) – Number of barrier sections per barrier I.
NP(I) – Number of plus and minus height increments per barrier I.
NRC – Total number of receivers in system model.
RNULL(I) – The "left-over" sound energy (in level antilog) that reaches each receiver I – without passing over any barrier elements.
RP(I,J) – The partial sound energy (in level antilog) for the receiver IRC – given as a function of barrier section number I and height J.

Subprogram Parameters

IFL – Output file number.
II – Sequential barrier section number on input to subprogram NBSET – relative barrier section number on exit from NBSET.
JJ – Number of the barrier containing the II barrier section.
JNP – Maximum index value for barrier height increments.

RESTRICTIONS: The subprogram outputs receiver information on partial sound energy values in coded form to file TAPE 8 – to be used later in program OPTIMA. Therefore, a physical device named TAPE 8 must be available during execution of STAMINA 2.0 – to be permanently saved for later use.

ACCURACY: Not applicable.

SIZE: 760

REFERENCES: None.

3.42 FUNCTION NBSET(NBAR,NBSM1,NB)

PURPOSE: This function subroutine is used to determine the relative barrier section number NBAR for barrier number NBSET. On input, NBAR is the sequential barrier section number. NBSET is used by OUTP2 to write the correct number of sound energy values for each barrier section.

SUBPROGRAMS USED: None.

VARIABLES: Input Parameters

NB – Total number of barriers in model.

NBAR – The sequential barrier section number – for which NBSET is to determine the barrier and the relative barrier section number.

NBSM1(I) – Number of barrier sections per barrier I.

Subprogram Parameters

N1,N2 – Used to accumulate barrier section numbers for comparison with NBAR.

Output Parameters

NBAR – Barrier section number relative to barrier number.

NBSET – Barrier numbers.

RESTRICTIONS: The input NBAR must be greater than zero and less than or equal to the cumulative barrier sections plus one.

ACCURACY: Not applicable.

SIZE: 508

REFERENCES: None.

3.43 SUBROUTINE PH(A,B,TEM1B,TEM1,INTEG,X1,X2,N,MR,MRC,FG,IBAR)

PURPOSE: PH computes the values of the partial sound energies for each barrier section at each height for each receiver to be used by program OPTIMA for noise barrier design. PH makes the same comparison of barrier attenuation to alpha factor attenuation as GEOMRY does, but PH does the comparison for each barrier height specified.

SUBPROGRAMS USED: Grade (X1,X2).

VARIABLES: Input Parameters

A — Atmospheric absorption parameter.
B — Shielding factor for roadway and receiver.
CQ(INDEX) — Value of reference standard deviation factor.
DELPN(IQ,IH) — Path length differences as a function of vehicle type and height perturbation.
FG — Ground attenuation factor.
IGOO(MR,N-1) — Grade designation per roadway per roadway section.
INTEG — Key used to indicate whether or not alpha factors being used in computation.
MR — Roadway number.
MRC — Receiver number.
N — Roadway section number.
NHP — Number of height perturbations.
NQ — Number of vehicle types.
NQS(MR,IQ) — Number of vehicle groups per vehicle type per roadway.
RP(IBAR,IH) — The partial sound energy values (in level antilogs) for each receiver--as a function of sequential barrier section number and barrier height perturbation.
TEM1 — Temporary variable (from GEOMRY).
TEM1B — Temporary variable (from GEOMRY) used in comparing effects of barrier vs. alpha factor excess attenuation.

VEXPH(MR,I,IQ) — Vehicle concentration per roadway per vehicle group per vehicle type.

XLREF(INDEX) — Value of reference acoustic intensity.

XR10 — Initial point of roadway section.

XR20 — Endpoint of roadway section.

Subprogram Parameters

BARRT — Temporary variable from GEOMRY--used in comparing barrier and alpha factor excess attenuation.

INDEX — Storage index for variable XLREF, computed by roadway number and vehicle type.

NQQ — Temporary value of number of vehicle groups per vehicle type per roadway, NQS(NR,NQ).

T1
T2
XTA — Temporary variables, used in computing. adjusted partial sound intensities--RP(IBAR,IH).

Output Parameters

RP(IBAR,IH) — Adjusted partial sound energy values, in level antilogs, for each receiver--as a function of barrier section number and barrier height perturbation.

RESTRICTIONS: None

SIZE: 1392

REFERENCES: None

4. STAMINA 2.0: DECLARED SIZE OF ARRAYS

4.1 PARAMETERS DEFINING THE PROBLEM

The basic parameters used by the prediction code and upon which the declared size of an array depends are as follows:

- Number of Roadways, NR: Declared as 30
- Number of Roadway Sections, NRSM1(NR): Declared as 14
- Number of Vehicle Types, NQ: Declared as 8
- Number of Traffic Flow Conditions on a Roadway, NQS(NR,NQ): Declared as 8
- Number of Receivers, NRC: Declared as 40
- Number of Octave Frequency Bands, NF: Declared as 1
- Number of Barriers, NB: Declared as 20
- Number of Barrier Segments, NBSM1(NB): Declared as 9
- Number of Ground Strips, NG: Declared as 10
- Number of Types of Ground Strips, IDUM(NG): Declared as 2
- Number of Allowable Reflections, IDXR: Declared as 10
- Number of Program Initialization Parameters, IP: Declared as 10

The following sections define the declared size of all arrays depending upon the above parameters. Arrays not explicitly presented in the following sections are used to describe coordinates in (x,y) space (declared as 2) or (x, y, z) space (declared as 3) and the usage should be evident to the user.

4.2 MAIN PROGRAM - GENERAL DIMENSION STATEMENTS

The arrays listed below with general dimension statements appear in the MAIN PROGRAM. The user should refer to the parameter list in Section 4.1

```
RDIN(IP)
XRC(NRC),YRC(NRC),ZRC(NRC)
NQS(NR,NQ)
XLE(NF)
```

```
GAMA(NR,NRC)
XMPH(NR,NQS,NQ),VEXPH(NR,NQS,NQ)
RX(NR,NRSM1+1),RY(NR,NRSM1+1),RZ(NR,NRSM1+1)
NRSM1(NR)
```

4.3 BLOCK DATA-GENERAL DIMENSION STATEMENTS

The arrays listed below with general dimension statements appear in BLOCK DATA. The user should refer to the parameter list in Section 4.1.

```
CO(NQ),C1(NQ),SO(NQ)
GAMA(NR,NRC)
```

4.4 SUBROUTINE INPUT-GENERAL DIMENSION STATEMENTS

The arrays listed below with general dimension statements appear in subroutine INPUT. The user should refer to the parameter list in Section 4.1.

```
NQS(NR,NQ),VTEMP(NQ)
BX(NB,NBSM1+1),BY(NB,NBSM1+1),BZ(NB,NBSM1+1)
 BLAST(NB),NBSM1(NB)
XXG1(NG,IDUM),YYG1(NG,IDUM), ZZG1(NG,IDUM)
BGS(NG),IDUM(NG)
RX(NR,NRSM1+1),RY(NR,NRSM1+1),RZ(NRSM1+1)
NRSM1(NR)
XMPH(NR,NQS,NQ),VEXPH(NR,NQS,NQ)
RDIN(IP)
XRC(NRC),YRC(NRC),ZRC(NRC)
CO(NQ),C1(NQ),SO(NQ)
GAMA(NR,NRC)
```

4.5 SUBROUTINE CHECK-GENERAL DIMENSION STATEMENTS

The arrays listed below with general dimension statements appear in subroutine CHECK. The user should refer to the parameter list in Section 4.1

```
BX(NB,NBSM1+1),BY(NB,NBSM1+1),BZ(NB,NBSM1+1)
 BLAST(NB),NBSM1(NB)
XXG1(NG,IDUM),YYG1(NG,IDUM),ZZG1(NG,IDUM)
BGS(NG),IDUM(NG)
RX(NR,NRSM1+1),RY(NR,NRSM1+1),RZ(NR,NRSM1+1)
NRSM1(NR)
```

4.6 SUBROUTINE INTER-GENERAL DIMENSION STATEMENTS

The arrays listed below with general dimension statements appear in subroutine INTER. The user should refer to the parameter list in Section 4.1.

```
CO(NQ),C1(NQ),SO(NQ)


XMPH(NR,NQS,NQ),VEXPH(NR,NQS,NQ),NQS(NR,NQ)
XLREF(NR*NQS*NF*NQ),CQ(NR*NQS*NF*NQ)
```

4.7 SUBROUTINE GEOMRY-GENERAL DIMENSION STATEMENTS

The arrays listed below with general dimension statements appear in subroutine GEOMRY. The user should refer to the parameter list in Section 4.1.

```
B1(3,2,NB*(NBSM1+1)),R1(3,2,NB*(NBSM1+1)),
RB1(3,2,NB*(NBSM1+1)),TA1(3,2,NG),
KBCODE(NB*(NBSM1+1)),KNUMB(NB*(NBSM1+1)),
KRNUMB(NB*(NBSM1+1)), KRDNUM(NB*(NBSM1+1))
KGCODE(NG),BGT(NG),IKIN(NG),BGS(NG),IDUM(NG),
DELPO(NQ),DELP1(NQ),DELP2(NQ),FB(NF,NQ),
DELR(NQ,IDXR),FG(NF),HGA(IDUM),
XIMG(3,IDXR),ZS(NQ),RDIN(IP),NQS(NR,NQ),
XLE(NF),XMPH(NR,NQS,NQ),VEXPH(NR,NQS,NQ),
BX(NB,NBSM1+1),BY(NB,NBSM1+1),BZ(NB,NBSM1+1),
 BLAST(NB),NBSM1(NB),XXG1(NG,IDUM),YYG1(NG,IDUM),
ZZG1(NG,IDUM),XLREF(NR*NQ*NF*NQS),
CQ(NR*NQ*NF*NQS).
GAMA(NR,NRC)
```

5. STAMINA 2.0: COMMON BLOCK DATA

Table 5-1, below, indicates the allocation of common block data within the STAMINA code. The definitions of the variables in each common block are provided on the following pages.

TABLE 5-1

ASSIGNMENT OF COMMON BLOCK DATA

COMMON BLOCK TITLE	MAIN PROGRAM	BLOCK DATA	INPUT	CHECK	INTER	DEGEN	GEOMRY	FILEO	FILEC	ENDPT	FNC1	FNC2	BARPRP	CDELP	OUTP1	OUTP2	PH	CONVER
/INOU/	●	●	●	●	x	●	●	x	x	●	x	x	●	x	x	x	x	x
/STORE1/	x	x	●	●	x	x	●	x	x	x	x	x	●	●	x	●	x	●
/STORE2/	x	x	●	●	x	x	●	x	x	x	x	x	x	x	x	x	x	●
/STORE3/	●	x	●	●	x	x	x	x	x	x	x	x	x	x	x	x	x	●
/STORE4/	●	x	●	x	●	x	●	x	x	x	x	x	x	x	x	x	●	●
/INPT1/	●	x	●	x	x	x	●	x	x	x	x	x	x	x	x	x	x	●
/INPT2/	●	x	●	●	x	x	●	x	x	x	x	x	x	x	x	x	x	●
/INPT3/	●	x	●	x	x	x	x	x	x	x	x	x	x	x	x	●	x	●
/DRIV2/	●	x	●	x	●	x	●	x	x	x	x	x	x	x	x	x	●	x
/DRIV3/	●	x	x	x	x	x	●	x	x	x	x	x	x	x	x	x	x	x
/DRIV4/	●	x	x	x	x	x	●	x	x	x	x	x	x	x	x	x	x	x
/BLK2/	●	x	●	x	x	x	●	x	x	x	x	x	x	x	x	x	●	●
/CONSTS/	x	●	●	x	●	x	x	x	x	x	x	x	x	x	x	x	x	●
/GEO1/	●	x	x	x	x	x	●	x	x	x	x	x	x	x	x	x	x	x
/INTER1/	x	x	x	x	●	x	●	x	x	x	x	x	x	x	x	x	●	x
/TTL/	●	●	●	x	x	x	x	x	x	x	x	x	x	x	●	x	x	x
/OPTION/	●	●	●	x	x	x	●	x	x	x	x	x	x	x	x	x	x	x
/TABLE/	●	●	●	x	x	x	●	x	x	x	x	x	x	x	x	x	●	x
/FUNC/	x	x	x	x	x	x	●	x	x	x	●	●	x	x	x	x	x	x
/BNEW/	●	●	●	x	x	x	●	x	x	x	x	x	●	●	●	●	●	●

● Denotes Assignment of Common

x Denotes No Assignment of Common

STAMINA 2.0 COMMON
BLOCK DEFINITIONS

COMMON BLOCK/INOU/ - HOLDS INPUT AND OUTPUT DEVICE NUMBER

INPT - DEVICE NUMBER FOR STAMINA DATA INPUT

IOUT - DEVICE NUMBER FOR STAMINA REPORT

IOT - DEVICE NUMBER FOR STAMINA MESSAGE FILE

COMMON BLOCK/STORE1/ - HOLDS BARRIER SECTION DATA

BX(20,12) - BARRIER SECTION X - COORDINATE ENDPOINT

BY(20,12) - BARRIER SECTION Y - COORDINATE ENDPOINT

BZ(20,12) - BARRIER SECTION Z - COORDINATE ENDPOINT

BLAST(20) - ASSOCIATED WITH TYPE OF LAST BARRIER SECTION PER BARRIER

NBSM1(20) - NUMBER OF SECTIONS PER BARRIER

COMMON BLOCK/STORE2/ - HOLDS GROUND STRIP DATA

XXG1(10, 2) - ABSORPTIVE GROUND STRIP X - COORDINATE ENDPOINT

YYG1(10, 2) - ABSORPTIVE GROUND STRIP Y - COORDINATE ENDPOINT

ZZG1(10, 2) - ABSORPTIVE GROUND STRIP Z - COORDINATE ENDPOINT

BGS(10) - WIDTHS OF ABSORPTIVE GROUND STRIPS

IDUM(10) - GROUND STRIP TYPE DESIGNATION

COMMON BLOCK/STORE3/ - HOLDS ROADWAY SECTION DATA

RX(30,17) - ROADWAY SECTION X - COORDINATE ENDPOINT

RY(30,17) - ROADWAY SECTION Y - COORDINATE ENDPOINT

RZ(30,17) - ROADWAY SECTION Z - COORDINATE ENDPOINT

NRSM1(30) - NUMBER OF SECTIONS PER ROADWAY

COMMON BLOCK/STORE4/ - HOLDS VEHICLE SPEED AND CONCENTRATION DATA

XMPH(30,1,8) - VEHICULAR SPEED PER ROADWAY PER VEHICLE GROUP PER VEHICLE TYPE

YEXPH(30,1,8) - VEHICULAR CONCENTRATION PER ROADWAY PER VEHICLE PER VEHICLE TYPE

COMMON BLOCK/INPT1/ - HOLDS INITIALIZATION PARAMETERS

RDIN(10) - INITIALIZATION PARAMETERS

COMMON BLOCK/INPT2/ - HOLDS NUMBERS OF ROADWAYS, BARRIERS, AND GROUND STRIPS

NR - NUMBER OF ROADWAYS

NB - NUMBER OF BARRIERS

NG - NUMBER OF GROUND STRIPS

COMMON BLOCK/INPT3/ - HOLDS RECEIVER DATA

XRC(40) - RECEIVER X - COORDINATE

YRC(40) - RECEIVER Y - COORDINATE

ZRC(40) - RECEIVER Z - COORDINATE

ALP(40) - 8 CHARACTER RECEIVER I.D.

RCTLE(10) - 80 CHARACTER DESCRIPTIVE HEADING FOR RECEIVER DATA

NRC - NUMBER OF RECEIVERS

COMMON BLOCK/DRIV2/ - HOLDS NUMBER OF VEHICLE GROUP DATA AND NUMBER OF FREQUENCY BANDS

NQS(30,8) - NUMBER OF VEHICLE GROUPS PER VEHICLE TYPE PER ROADWAY

NF - NUMBER OF FREQUENCY BANDS

COMMON BLOCK/DRIV3/ - HOLDS MEAN INTENSITY

XLE(9) - MEAN INTENSITY

COMMON BLOCK/DRIV4/ - HOLDS STATISTICAL VARIABLE DATA FOR COMPUTATIONS

CAP2 - STATISTICAL VARIABLE FOR COMPUTATION

COMMON BLOCK/BLK2/ - HOLDS NUMBER OF VEHICLE TYPES

NQ - NUMBER OF VEHICLE TYPES

COMMON BLOCK/CONSTS/ - HOLDS CONSTANTS FOR SOUND SPECTRA

C0(8) - SOUND LEVEL SPECTRA PRESENT FOR VEHICLE TYPES 1, 2, and 3

C1(8) - SOUND LEVEL SPECTRA PRESENT FOR USER DEFINED TYPES (4 OR GREATER)

S0(8) - STANDARD DEVIATION OF SOUND LEVEL SPECTRA

COMMON BLOCK/GEO1/ - HOLDS BARRIER, SECTION, AND GROUND STRIP NUMBERS

IBAR - BARRIER NUMBER

ISEG - BARRIER SECTION NUMBER

IGRA - GROUND STRIP NUMBER

COMMON BLOCK/INTER1/ - HOLDS CONSTANTS FOR VECTOR NOTATION AND STANDARD DEVIATION

XLREF(240) - VECTOR NOTATION FOR REFERENCE INTENSITIES

CQ(240) - FACTOR ACCOUNTING FOR STANDARD DEVIATION OF REFERENCE LEVEL

COMMON BLOCK/TTL/ - HOLDS ALPHANUMERIC TITLES

TITLE(80) - 80 CHARACTER PROBLEM TITLE

VTITLE(5,2) - 16 CHARACTER VEHICLE TITLE

COMMON BLOCK/OPTION/ - HOLDS USER SUPPLIED OPTION DATA

METIN - OPTION FLAG FOR INPUT UNITS

METOUT - OPTION FLAG FOR OUTPUT UNIT

IREFL - OPTION FLAG FOR COMPUTED REFLECTIONS

COMMON BLOCK/TABLE/ - HOLDS GRADE DESIGNATION AND ALPHA FACTOR DATA

GAMA(30,40) - ALPHA FACTOR MATRIX

IGOO(30,17) - GRADE DESIGNATION PER ROADWAY PER ROADWAY SECTION

N - INDEX FOR ROAD SECTION NUMBER

COMMON BLOCK/FUNC/ - HOLDS ALPHA FACTORS

XGAM - SET EQUAL TO VARIOUS ALPHA FACTORS

COMMON BLOCK/BNEW/ - HOLDS VARIOUS BARRIER AND SOUND DATA INCORPORATED IN THIS VERSION

ZO(20,12) - ZERO HEIGHTS PER BARRIER PER BARRIER SECTION

DZ(20) - AREA HEIGHT INCREMENT PER BARRIER

BT(20,12) - 8 CHARACTER TITLE FOR BARRIER SECTION

TR(30,40) - SHIELDING FACTOR MATRIX

RNULL(40) - LEFT OVER SOUND ENERGY THAT REACHES THE RECEIVER WITHOUT PASSING OVER ANY BARRIER

RP(240,8) - PARTIAL SOUND INTENSITIES FOR EACH RECEIVER (IN LEVEL ANTILOGS)

SBL(240) - BARRIER SECTION LENGTH PER BARRIER SECTION

DELPN(8,8) - THE PATH LENGTH DIFFERENCES, AS A FUNCTION OF VEHICLE TYPE AND HEIGHT PERTURBATION.

NBSEC - COUNTER FOR NUMBER OF BARRIER SECTIONS INPUT PER BARRIER

NHP - NUMBER OF HEIGHT PERTURBATIONS

NP(20) - NUMBER OF ± PERTURBATIONS PER BARRIER

IST(20,13) - ROADWAY NUMBERS ASSOCIATED WITH STRUCTURED BARRIERS

6. OPTIMA: ARCHITECTURE OF THE OPTIMA PROGRAM

6.1 Introduction

OPTIMA is a time-sharing program used in conjunction with the STAMINA 2.0 program. STAMINA 2.0 is assumed to have been executed, having computed the barrier parameters (including noise reduction effectiveness in terms of sound energy values) required by OPTIMA. An output file from STAMINA 2.0 is assumed to be present in a secondary storage device containing barrier height and length data and corresponding partial sound energy values (in level antilog) at each receiver. Once this file is read in by OPTIMA, the user can interact with OPTIMA, selecting various barrier heights and examining the resultant effectiveness and cost implications.

The program is written in FORTRAN IV language and is intended to run in a time-sharing mode. This section describes the main program in OPTIMA, and the following section contains complete descriptions of the subprograms used in OPTIMA.

6.2 Main Program Description

The main program controls the flow of operations required in execution of OPTIMA (see Fig. 6-1). The program assumes that several files have been allocated prior to execution. File TAPE 24 contains the data output by STAMINA 2.0. File TAPE 5 is the input/output time-sharing file used in reading and echoing the user's barrier selection information. All interactive responses are produced using TAPE 5. File TAPE 20 is a secondary file containing all printed output from OPTIMA; it can be saved for later reference. File TAPE 6 should also be allocated to receive any system print messages that might have been issued during execution.

The main program first initializes key parameters defining files to be used and starting variables. It then prints, to the time-sharing terminal, program headings and file control options. Then it calls FILES to establish file names used as input and output in the program. The user can select output to the terminal as well as the complete listing file — TAPE 20.

Upon establishing file control, the main program will issue headings to the appropriate output files concerning receiver and barrier information. The subprogram LINK is then called to read receiver and barrier data, as produced by STAMINA 2.0, from file TAPE 24. All data from this file are obtained using "self-sufficient READ's;" that is – the format in which the file was created by STAMINA 2.0 is acceptable to OPTIMA. The user need not specify any information concerning the previously run STAMINA 2.0.

Subprogram COST is then called to allow the user to select the material type of each barrier section....wood, steel, etc. The user is then prompted to input the number of people and design noise level per receiver. Once the information is input, summary tables for the barrier material selection and receiver parameters are output.

The main program then varies the barrier section number to compute costs per linear foot. For each barrier section, the height perturbation index is varied in order to compute barrier cost factors per linear foot and per foot of barrier height (performed in subprogram LINP).

Upon computing unit barrier costs, the main program calls subprogram BAICB, which calculates the effectiveness/cost ratios – as a function of increasing height, for all barrier sections in the system (see User's Manual Appendix Sec. A.10 for details). The table of these effectiveness/cost ratios, for each barrier section as a function of height, is then printed by subprogram BCBO. This table is studied by the user to select barrier heights in an effort to determine a cost-efficient barrier system design.

The above sequence is made only once per OPTIMA run. The subprograms TERMAL and TYMSHR may be called by the user as many times as desired so that the user may examine the noise level and cost implications of many barrier designs. Subprogram TERMAL is called by the main program to prompt the user to select (with the aid of the effectiveness/cost ratios table) the barrier height indices for a design configuration. The other function of this subprogram is to end execution of OPTIMA. If the user chooses to end execution, TERMAL will close all files that were opened during the run. (This function's structure may vary among computer systems.)

Subprogram TYMSHR is called by the main program to compute and print the LEQ's (predicted energy-average overall A-weighted sound levels) for each receiver for barrier configuration selected. Also, the costs per barrier material type and total cost for the selected barrier design are calculated and printed.

6.3 Main Program Variables and Flow Diagram

Input Parameters

BTBLE (IB) — Barrier type-number table.

DELZ (IB,I) — Barrier section height increment.

NB — Number of barriers.

NBSMI (40) — Number of segments per barrier.

NP (JJ) — Number of plus and minus height increments per barrier.

Subroutine Parameters

BTN — Barrier type index.

CST — Temporary variable — barrier cost per linear foot at specific height.

CSTPR — Temporary variable — barrier cost per linear foot at one height increment (DELZ) lower than in CST (above).

II — Sequential barrier number — input to NBSET.

IN — Input file number.

IO — Output file number.

IPASS — Counter indicating first selection of barrier design.

IPPI — Number of barrier height increments.

JJ – Actual barrier number returned by NBSET.

ZETA (IB,I) – Barrier heights associated with the final effectiveness/cost ratios.

Output Parameters

CB (IB,I) – Change in barrier cost per linear foot between two consecutive heights of a barrier section.

SIZE: 1098

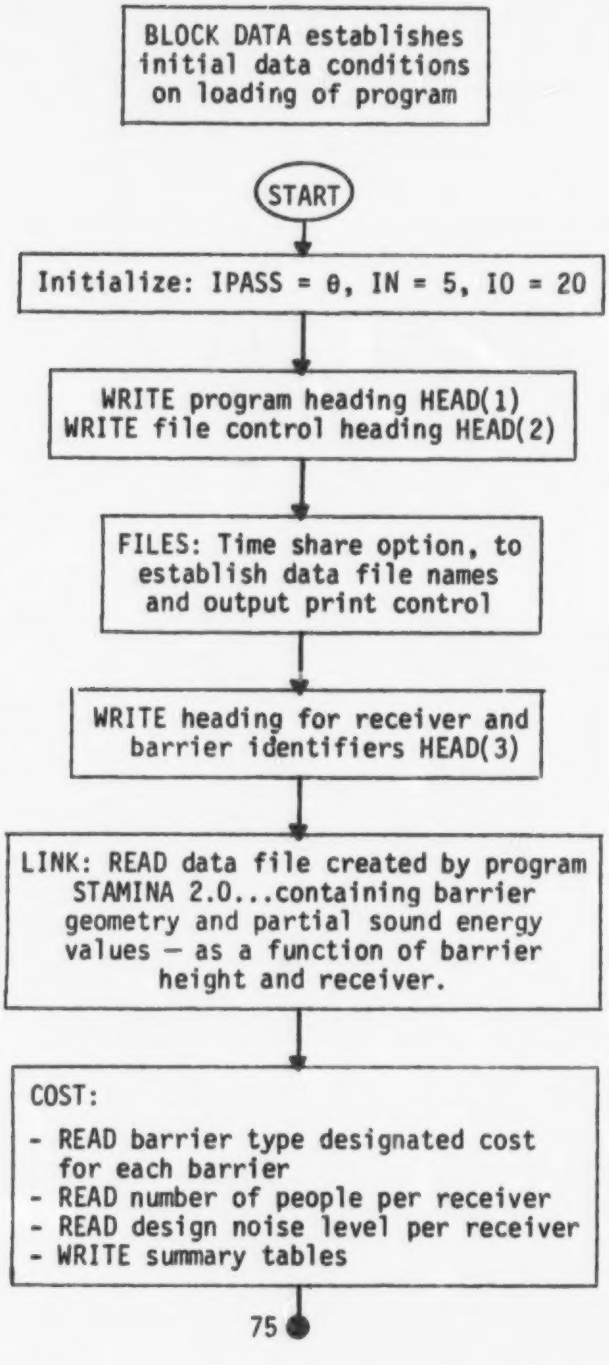
BLOCK DATA establishes initial data conditions on loading of program
START
Initialize: IPASS = 0, IN = 5, IO = 20
WRITE program heading HEAD(1)
WRITE file control heading HEAD(2)
FILES: Time share option, to establish data file names and output print control
WRITE heading for receiver and barrier identifiers HEAD(3)
LINK: READ data file created by program STAMINA 2.0...containing barrier geometry and partial sound energy values — as a function of barrier height and receiver.
COST:
- READ barrier type designated cost for each barrier
- READ number of people per receiver
- READ design noise level per receiver
- WRITE summary tables
75

FIGURE 6-1: OPTIMA FLOW DIAGRAM

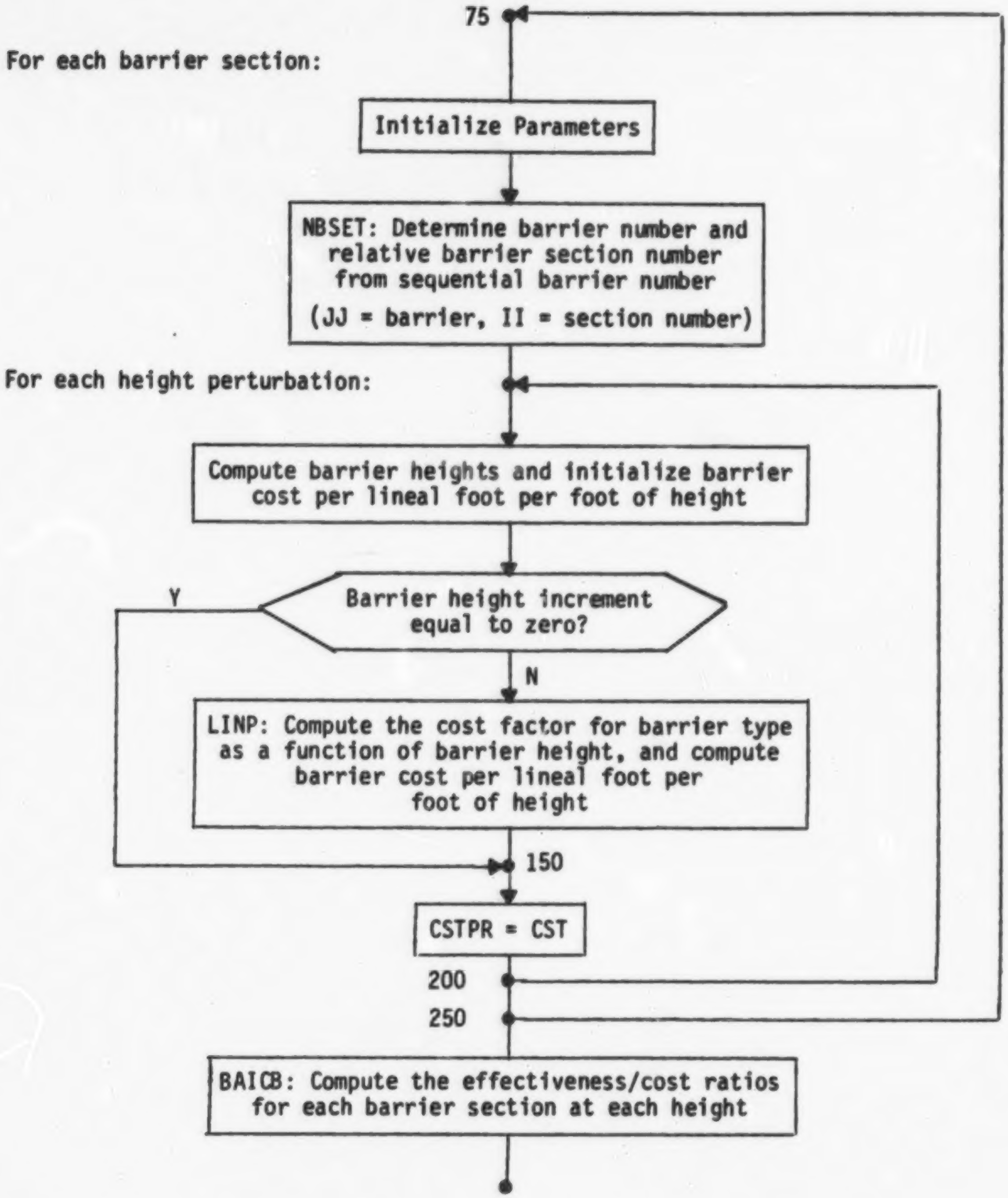
75
For each barrier section:
Initialize Parameters
NBSET: Determine barrier number and relative barrier section number from sequential barrier number
(JJ = barrier, II = section number)
For each height perturbation:
Compute barrier heights and initialize barrier cost per lineal foot per foot of height
Y
Barrier height increment equal to zero?
N
LINP: Compute the cost factor for barrier type as a function of barrier height, and compute barrier cost per lineal foot per foot of height
150
CSTPR = CST
200
250
BAICB: Compute the effectiveness/cost ratios for each barrier section at each height

FIGURE 6-1: OPTIMA FLOW DIAGRAM (continued)

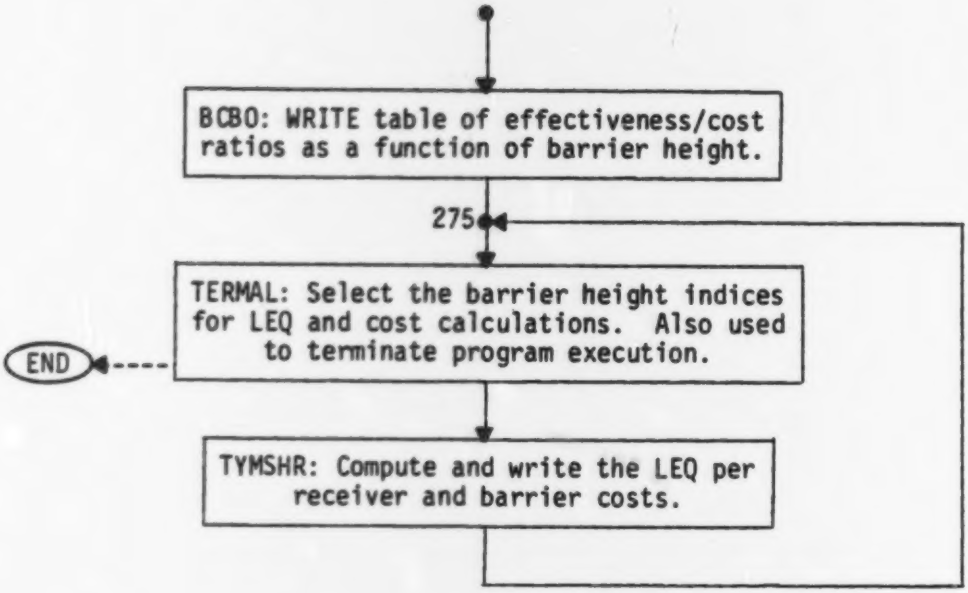
BCBO: WRITE table of effectiveness/cost ratios as a function of barrier height.
275
TERMAL: Select the barrier height indices for LEQ and cost calculations. Also used to terminate program execution.
END
TYMSHR: Compute and write the LEQ per receiver and barrier costs.

FIGURE 6-1: OPTIMA FLOW DIAGRAM (Concluded)

7. OPTIMA: SUBPROGRAM DESCRIPTIONS

This section contains descriptions of the eleven subprograms contained in the barrier optimization program OPTIMA. Among these subprograms are an initialization routine (BLOCK DATA), nine subroutines, and one function subprogram. Each subprogram is described independently according to the following format:

PURPOSE:	The purpose of the subprogram is described.
SUBPROGRAMS USED:	The subprograms used by the subprogram are listed.
VARIABLES:	Input, subprogram, and output parameters, respectively.
ACCURACY:	If applicable.
SIZE:	In hexadecimal bytes.
REFERENCES:	If any.
FIGURES:	As necessary for adequate description.

The subprograms are described sequentially, as they appear in the overall program list.

7.1 BLOCK DATA

PURPOSE: The routine BLOCK DATA is used to set variables during loading of the computer programs. The principle variables set are associated with barrier material and construction costs. (The costs, in this particular version, correspond to costs in the year 1977.) The material types included in the routine are: Berm, Masonry, Wood, Concrete, and Steel. (The user may set 45 additional material types if desired.)

VARIABLES: Output Parameters

BTNME (NTYPES) — The material type names (8 character maximum) per material type.

CPLF (NBH, NTYPES) — Barrier cost per linear foot, as a function of height and material type.

NBH — Maximum number of height increments.

NTYPES — Number of material types presently used in program (≥ 5).

RESTRICTIONS: This routine is used to initialize construction costs of barriers. If a user wishes to modify costs or add material types, the program must be recompiled, changing: NTYPES to the total number of materials included in the new list and CPLP (I,J) to the new barrier costs (per linear foot as a function of material type I and barrier height J). The height increments (BH array) are described in the variable lists. The material name must be 8 characters (or less) and must be added to the BTNME data list.

ACCURACY: Not applicable.

SIZE: Not applicable.

REFERENCES: None.

7.2 Subroutine FILES

PURPOSE: FILES is called by OPTIMA to establish file names used as input and output to the program. The time-sharing user can select output to the terminal as well as the storage of a "complete listing file" TAPE 20.

SUBPROGRAMS USED: Head.

RESTRICTIONS: None.

ACCURACY: Not applicable.

SIZE: 372

REFERENCES: None.

7.3 Subroutine LINK

PURPOSE: This routine is called upon by OPTIMA to read the receiver and barrier data, produced by STAMINA 2.0, from file TAPE 24.

SUBPROGRAMS USED: NBSET (II,NBSMI,NB)

VARIABLES:

Input Parameters

BOTH — Logical IF variable
ITP — File name (FILE 24 from STAMINA 2.0)
NB — Number of barriers
NBSM1(I) — Number of segments per barrier
NP(JJ) — Number of plus and minus barrier height changes per barrier

Subroutine Parameters

II — Sequential barrier section number
JJ — Barrier number from NBSET
JNP — Temporary index for number of barrier height perturbations
P — Number of plus and minus barrier height changes

General Parameters

B — Total number of barrier sections
BARR(I) — Barrier I.D. (8 characters)
DELZ(I,J) — Barrier section height increments
INULL(IRC) — "Left-over" sound energy - no barriers
IRC — Receiver number
ITN(I,J,IRC) — Partial sound energy values
LGTH(I) — Length of barrier section
R — Number of receivers
RECNM(IRC) — Receiver I.D. (8 character)
TPP1 — = 2 * NP + 1....maximum number of height perturbations for any barrier

TPP2 — = TPP1 + 1....maximum number of barrier heights for any barrier

RESTRICTIONS: The routine operates under the assumption that FILE 24 (input file from STAMINA 2.0) is present, as well as FILE 20 for output.

ACCURACY: Only that of subprogram NBSET

SIZE: 1684

REFERENCES: None

7.4 Subroutine COST

PURPOSE: This routine permits the user to select the material type of each barrier in the system model – wood, steel, concrete, etc. It then prompts the user to input the number of people and design noise level associated with each receiver. Once the information is input, summary tables are printed at the terminal.

SUBPROGRAMS USED: Head

VARIABLES:

Input Parameters

BOTH – Logical IF variable
BTBLE(IB) – Barrier section type number table
R – Receiver number

Subroutine Parameters

BTN – Barrier section type
N – Number of receivers
VDFALT – Default constant for exterior design noise level

Output Parameters

BARR(IB) – Barrier I.D. (8 character)
BTNME(BTN) – Barrier section type
RECNM(I) – Receiver I.D. (8 character)
U(I) – Number of people represented per receiver
V(I) – Exterior design noise level per receiver

RESTRICTIONS:

1) Barrier section type number (BTBLE) entries must be nonzero and less than or equal to NTYPES (normally set to 5).
2) Number of people per receiver (U(I)) may be zero; however, there is no default value.
3) If design noise level per receiver (V(I)) is input as zero, program defaults value to 67 dBA (LEQ).

ACCURACY: Not applicable

SIZE: 1782

REFERENCES: None

7.5 Subroutine LINP

PURPOSE: This subroutine is called (by OPTIMA) to compute barrier costs per linear foot for specific barrier sections at different heights.

SUBPROGRAMS USED: None

VARIABLES: Input Parameters

ARG — Temporary variable....barrier height

BH(I) — Barrier height increments; initialized in BLOCK DATA

CPLF(I,ITY) — Barrier costs per linear foot, as a function of height and type

NBH — Total number of barrier height increments contained in BH(I)

Subroutine Parameters

$\left.\begin{array}{l}\text{TEM1 —}\\ \text{TEM2 —}\end{array}\right\{$ Interpolative constants used in calculations of cost per linear foot (ANS)

Output Parameters

ANS — Barrier cost per linear foot

RESTRICTIONS: None

ACCURACY: Not applicable

SIZE: 676

REFERENCES: None

7.6 Subroutine BAICB

PURPOSE: This subroutine calcualtes the effectiveness/cost ratios, as a function of height, for all barrier sections in the system.

SUBPROGRAMS USED: NBSET(II,NBSMI,NB)

VARIABLES: Input Parameters

CB(IB,I) — Change in barrier cost per linear foot between two consecutive heights of a barrier section

DELZ(IB,I) — Barrier section height increments

ITN(IB,I,J) — Partial sound energy values for each barrier section, barrier section height, and receiver

LGTH(IB) — Lengths of barrier sections

NB — Number of barriers

NBSM1(40) — Number of sections per barrier

NP(JJ) — Number of plus and minus height changes per barrier

U(I) — Number of people represented per receiver

V(I) — Exterior design noise level per receiver

Subroutine Parameters

DELI — Difference between partial sound energy values for two consecutive heights of a barrier section

DENOM — Difference in cost between two consecutive heights of a barrier section

IL — Sequential barrier section number....becomes relative section number

IP — = 2 * NP + 1....number of barrier height perturbations

JJ — Barrier number from NBSET

PN — Computational accumulator for all receivers of the population and DNL-weighted partial energy differences, DELI

Output Parameters

ETA(IB,I) – Effectiveness/cost ratio due to increasing barrier height for each barrier section and height. Equals PN/DENOM, above. Corresponds to $\theta_{b,i}$ of Eq. A-30, User's Manual appendix.

TN(J) – Population and design noise level weighting factor for partial energy values

RESTRICTIONS: None

ACCURACY: Restricted only by that of subprograms used

SIZE: 1130

REFERENCES: None

7.7 Subroutine BCBO

PURPOSE: This subroutine prints out the matrix of effectiveness/cost ratios and corresponding barrier heights needed by the user to select cost-efficient barrier design.

SUBPROGRAMS USED: NBSET(II,NBSM1,NB)

VARIABLES: Input Parameters

BARR(IB) — Barrier section identifications

BOTH — Logical IF variable

NB — Number of barriers

NBSM1(40) — Number of sections per barrier

TPP2 — = TPP1 + 1....maximum (over all barriers) number of barrier heights

Subroutine Parameters

ARG — Temporary variable....ETA(IB,IPP1)

ARG1 — Temporary variable....product of ETA(IB,I) and ETA(IB,I-1)

II — Sequential barrier section number....becomes relative section number

IPP1 — Number of height perturbations for a barrier section

IPP2 — = IPP1 + 1....number of heights for a barrier section

JJ — Barrier number returned from NBSET

Output Parameters

ETA(IB,I) — Effectiveness/cost ratio due to increasing barrier height for each barrier section and height. Corresponds to $\theta_{b,i}$ of Eq. A-30 of User's Manual appendix.

ETAPRT(I) — Final value of effectiveness/cost ratio that is output to terminal. This is a decibel-like quantity, corresponding to $\xi_{b,i}$ of Eq. A-34 of User's Manual appendix.

ETASP — Final effectiveness/cost ratio for the highest barrier height

ZETA(IB,I) — Barrier section height aboveground corresponding to effectiveness/cost ratios

RESTRICTIONS: None

ACCURACY: Reliant only upon that of NBSET

SIZE: 3330

REFERENCES: None

7.8 Subroutine TERMAL

PURPOSE: TERMAL enables the user to select (aided by the effectiveness/cost ratios table) the various barrier height indices for a barrier design configuration. It also serves to end the execution of OPTIMA, at the user's command, by closing all files opened during the run. This latter function's actual structure may be required to change for different computer systems.

SUBPROGRAMS USED: Head

VARIABLES: Input Parameters

ANS — Barrier cost per linear foot
B — Total number of barrier sections

Subroutine Parameters

IPASS — Counter-indicating first selection of barrier design
XNO — Alpha constant "Y" or "N" — response parameter, tested for termination of run

Output Parameters

HBT(IB) — Barrier section height selection index

RESTRICTIONS:

1) Entries for the section height increment selection index (HBT) must be nonzero and less than or equal to IPP2.
2) Any options, concerning output file control, must be exercised at this point in program.

ACCURACY: Not applicable

SIZE: 2238

REFERENCE: None

7.9 Subroutine TYMSHR

PURPOSE: Subroutine TYMSHR is called by OPTIMA to compute the LEQ's (predicted energy-average overall A-weighted sound level) for each receiver for each barrier configuration. The individual costs-per-material type and total costs for the selected barrier are also calculated and printed.

SUBPROGRAMS USED: Head

VARIABLES:

Input Parameters

BOTH — Logical IF variable
BTBLE(IB) — Barrier section-type number table
CB(IB,I) — Cost-benefit ratio as a function of barrier and height increment
DELZ(IB,I) — Barrier section height increment
HBT(IB) — Barrier section height selection indices
INULL(J) — The "left-over" sound energy that reaches the receiver without passing over a barrier
ITN(IB,HBX,J) — Partial sound energy values from STAMINA 2.0
LGTH(IB) — Length of barrier section
NTYPES — Number of different barrier materials used in program (≥5)

Subroutine Parameters

BTN — Barrier type index
HBX — = HBT(IB) - 1 — section height index minus one
LEQS — Accumulator (over all barriers) of sound energy (in level antilog)

Output Parameters

BTNME(BTN) — Barrier section type
COST(BTN) — Cumulative cost variable per barrier type

LEQN(IR) — Cumulative (over all barrier sections plus INULL) sound level, in dBA, per receiver

RECNM(IR) — Receiver I.D. (8 character)

TCB — Total cost of barrier — sum of all types

RESTRICTIONS: None

ACCURACY: Not applicable

SIZE: 1850

REFERENCES: None

7.10 Function NBSET(NBAR,NBSM1,BN)

PURPOSE: This function subroutine is used to determine the relative barrier section number NBAR for barrier number NBSET. On input, NBAR is the sequential barrier section number.

SUBPROGRAMS USED: None

VARIABLES: Input Parameters

NB — Total number of barriers in model

NBAR — The sequential barrier section number for which NBSET is to determine the barrier and the relative section number

NBSM1(I) — Number of barrier sections per barrier I

Subprogram Parameters

N1,N2 — Used to accumulate barrier section numbers for comparison with NBAR

Output Parameters

NBAR — Barrier section number relative to barrier number

NBSET — Barrier numbers

RESTRICTIONS: The input NBAR must be greater than zero and less than or equal to the cumulative barrier sections plus one.

ACCURACY: Not applicable

SIZE: 508

REFERENCES: None

7.11 Subroutine HEAD(N)

PURPOSE: This subroutine provides properly formatted section headings, as needed, throughout the execution of OPTIMA.

VARIABLES: Input Parameters

BOTH — Logical IF variable

N — Number of receivers

NTYPES — Number of different barrier materials used in program (≥5)

Output Parameters

BTNME(I) — Barrier section type

RESTRICTIONS: None

ACCURACY: Not applicable

SIZE: 1724

REFERENCES: None

7.12 Subroutine ZOLEQ

PURPOSE: This subroutine calculates the LEQ(H) at the Z0 ground height.

SUBPROGRAMS USED: None

VARIABLES: Input Parameters

N = Number of receivers

B = Total Number of Barrier Sections

ITN (B,1,N) = Sound Energy at Each Barrier Section at Z0 Height.

INULL (N) = Left Over Sound Energy for Each Receiver.

Output Parameters

ZLEQ (N) - LEQ (H) at each receiver.

RESTRICTIONS: None

ACCURACY: Not Applicable

SIZE: 470

REFERENCES: None

8. OPTIMA: DECLARED SIZE OF ARRAYS

8.1 Parameters Defining the Problem

The basic parameters used by the OPTIMA program and upon which the delcared size of an array depends are as follows:

Definition	Symbol	Declared Value
• Number (sequential) of barrier sections	B	100
• Number of plus and minus height perturbations	P	3
• Number of receivers	R	40
• Number of barriers	NB	20
• Number of barrier height indices	NBH	8
• Number of barrier types (wood, steel, etc.)	NTYPES	5 maximum (50)

The arrays listed below, with general dimension statements, appear throughout the program.

Array		Description
BARR(B)	—	Barrier section identifier
BH(NBH)	—	Barrier height table used for computing CST/LNFT
BTBLE(B)	—	Barrier section type code
BTNME(NTYPES)	—	Barrier type identifiers
CB(B,NBH-1)	—	Change in barrier cost per linear foot between two consecutive heights of a barrier section
CPLF(NBH,NTYPES)	—	Barrier costs per linear foot, as a function of height and type
DELZ(B,NBH-1)	—	Barrier section height increments
ETA(B,NBH-1)	—	Effectiveness/cost ratio due to increasing barrier height for each barrier section and height. Corresponds to $\theta_{b,i}$ in Eq. A-30, User's Manual appendix

INULL(R) – "Left-over" sound energy that does not pass over any barrier sections

ITN(B,2P+2,R) – Partial sound energy values for each barrier section, barrier section height, and receiver

LGTH(B) – Length of barrier section B

NBSM1(NB) – Number of barrier sections per barrier

NP(B) – Number of plus and minus height increments per barrier section

RECNM(R) – Receiver identifiers

U(R) – Number of people represented by each receiver

V(R) – Exterior design noise level for each receiver

ZETA(B,NBH) – Heights of barrier sections aboveground height for each barrier

ZLEQ(R) – Zero height DBA level at each receiver.

9. OPTIMA: COMMON BLOCK DATA

Table 9.1, below, indicates the allocation of common block data within the cost optimizing program OPTIMA. The definition of the variables in each common block are provided on the following pages.

TABLE 9.1

ASSIGNMENT OF COMMON BLOCK DATA

COMMON BLOCK TITLE	OPTIMA	BLOCK DATA	FILES	LINK	COST	LINP	BAICB	BCBO	TERMAL	TYMSHR	HEAD	ZOLEQ
/BAICB1/	x	x	x	x	x	x	●	●	x	x	x	x
/BLK2/	x	●	x	x	x	●	x	x	x	x	x	x
/BLK3/	x	●	x	x	●	x	x	x	x	●	●	x
/COST1/	●	x	x	x	●	x	x	x	x	●	x	x
/COST2/	x	x	x	x	●	x	●	●	●	●	x	●
/INOU/	●	x	●	●	●	x	●	●	●	●	●	x
/LINK1/	●	x	x	●	●	x	●	●	●	●	x	●
/MAIN2/	●	x	x	x	x	x	●	●	●	●	x	x
/TERML1/	x	x	x	x	x	x	x	x	●	●	x	x
/TERML2/	●	x	x	x	x	x	x	x	●	x	x	x
/EXTRA/	●	x	x	●	●	x	x	x	●	●	●	●

● Denotes assignment
x Denotes no assignment

OPTIMA COMMON BLOCK
DEFINITIONS

COMMON BLOCK/BAICB1/ - HOLDS EFFECTIVENESS/COST RATIOS

ETA(100,7) - EFFECTIVENESS/COST RATIO DUE TO INCREASING BARRIER HEIGHT FOR EACH BARRIER SECTION AND HEIGHT

COMMON BLOCK/BLK2/ - HOLDS BARRIER HEIGHT AND COST DATA

BH(8) - BARRIER HEIGHTS USED IN PROGRAM

CPLF(8,50) - BARRIER COST PER LINEAR FOOT, AS A FUNCTION OF HEIGHT AND MATERIAL TYPE

NBH - MAXIMUM NUMBER OF HEIGHT INCREMENTS

COMMON BLOCK/BLK3/ - HOLDS MATERIAL TYPE DATA

BTNME(50) - 8 CHARACTER MATERIAL TYPE NAMES

NTYPES - NUMBER OF MATERIAL TYPES PRESENTLY USED IN PROGRAM (≥ 5).

COMMON BLOCK/COST1/ - HOLDS BARRIER TYPE AND NUMBER DATA

BTBLE(100) - BARRIER TYPE AND NUMBER TABLE

COMMON BLOCK/COST2/ - HOLDS NUMBER OF RECEIVERS, DESIGN NOISE LEVELS, AND PEOPLE PER RECEIVER

U(40) - NUMBER OF PEOPLE REPRESENTED PER RECEIVER

V(40) - EXTERIOR DESIGN NOISE LEVEL PER RECEIVER

N - NUMBER OF RECEIVERS

COMMON BLOCK/INOU/ - HOLDS INPUT AND OUTPUT FILE DATA

IN - INPUT FILE NUMBER

IO - OUTPUT FILE NUMBER

ITP - FILE CREATED BY STAMINA 2.0 PROGRAM

BOTH - LOGICAL IF USED TO TELL THE PROGRAM WHETHER OR NOT BOTH OUTPUT FILES WILL BE GENERATED

FILOUT - OUTPUT FILE NUMBER

COMMON BLOCK/LINK1/ - HOLDS RECEIVER AND BARRIER SEGMENT TITLES ALONG WITH HEIGHT INCREMENTS, SOUND LEVEL DATA AND NUMBERS OF RECEIVERS AND BARRIERS

RECNM(40) - 8 CHARACTER RECEIVER I.D.

BARR(100) - 8 CHARACTER BARRIER I.D.

INULL(40) - LEFT OVER SOUND ENERGY - NO BARRIERS

LGTH(100) - LENGTH OF BARRIER SECTION

DELZ(100,7) - BARRIER SECTION HEIGHT INCREMENTS

ITN(100,8,40) - PARTIAL SOUND ENERGY VALUES

B - TOTAL NUMBER OF BARRIER SECTIONS

P - NUMBER OF PLUS AND MINUS BARRIER HEIGHT CHANGES

R - NUMBER OF RECEIVERS

TPP1 - MAXIMUM NUMBER OF HEIGHT PERTURBATIONS FOR ANY BARRIER

TPP2 - MAXIMUM NUMBER OF BARRIER HEIGHTS FOR ANY BARRIER

NB - NUMBER OF BARRIERS

NBSM1(40) - NUMBER OF SEGMENTS PER BARRIER

NP(100) - NUMBER OF PLUS OR MINUS BARRIER HEIGHT CHANGES PER BARRIER

COMMON BLOCK/MAIN2/

ZETA(100,8) - BARRIER HEIGHTS ASSOCIATED WITH THE FINAL EFFECTIVENESS/COST RATIOS

CB(100, 7) - CHANGE IN BARRIER COST PER LINEAR FOOT BETWEEN TWO CONSECUTIVE HEIGHTS OF A BARRIER SECTION

COMMON BLOCK/TERML1/ - HOLDS BARRIER SECTION HEIGHT SELECTIONS

HBT(100) - BARRIER SECTION HEIGHT SELECTION INDEX

COMMON BLOCK/TERML2/ - HOLDS COUNTER INDICATING FIRST SELECTION OF BARRIER DESIGN

IPASS - COUNTER INDICATING FIRST SELECTION OF BARRIER DESIGN

COMMON BLOCK/EXTRA/ - HOLDS VARIABLE FOR TITLE AND ZERO HEIGHT LEQ

TITLE(20) - 80 CHARACTER TITLE PASSED FROM STAMINA

PTITL(20) - 80 CHARACTER TITLE FOR EACH BARRIER DESIGN

ZLEQ(40) - ZERO HEIGHT LEQ FOR EACH RECEIVER

10. OPERATIONS MANUAL

10.1 INTRODUCTION

The operations manual for the STAMINA 2.0 and OPTIMA computer programs describes the operational environments of the two separately and the associated file structures of each. In general, STAMINA 2.0 is a batch-run program, while OPTIMA operates in a time-sharing mode. The purpose of STAMINA 2.0 is to generate sufficient acoustic information for various permutations of barrier design during a single run and then save the information on a permanent file for later use in OPTIMA. OPTIMA is then used in an interactive mode, testing many different barrier system configurations in an effort to optimize the barrier design with respect to cost and effectiveness.

10.2 OVERVIEW OF PROGRAMS

Both STAMINA 2.0 and OPTIMA are written in standard FORTRAN IV language for an IBM computer system. Generally, there are no system dependencies, other than possible list-directed (free field) idiosyncracies from one machine to another. Included in both programs are commented sections, designed to be used for the opening and closing of files during execution, for user convenience. Both programs can be compiled without special routines or libraries. Load modules can be saved for standard execution of the programs. If any limiting variables or array sizes are to be changed, a new load module must be created and saved.

If data files are not opened or closed within the programs, a procedure file or job control should be created, to aid the user in handling input and output of permanent storage files for STAMINA 2.0 and OPTIMA.

Figure 10-1 illustrates the two basic phases of the combined STAMINA-OPTIMA execution and the use of the data files. Note that STAMINA 2.0 must be executed before OPTIMA can be run. Once STAMINA 2.0 has generated file TAPE 8, many OPTIMA runs can be made.

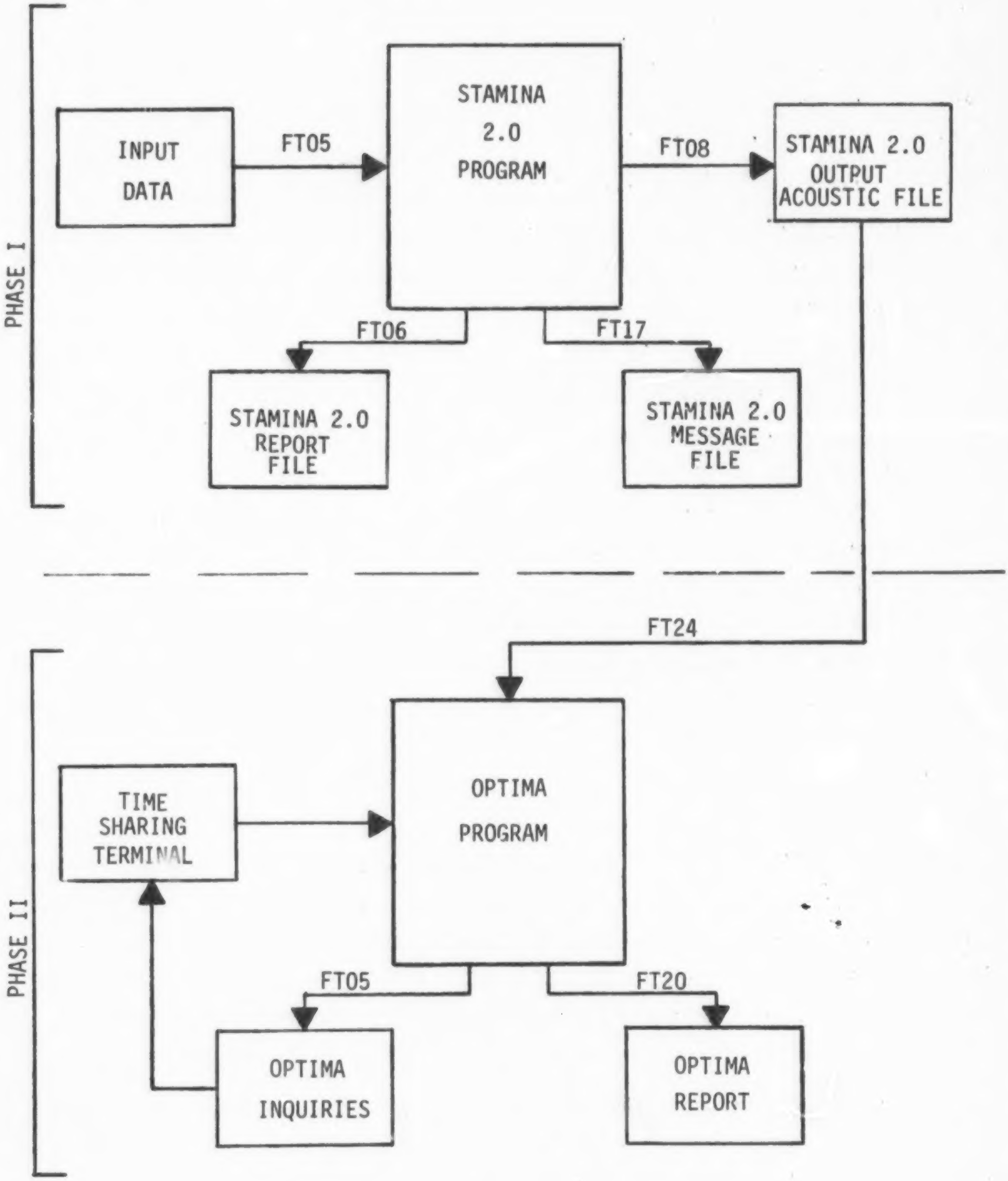

FIGURE 10-1 STAMINA 2.0 - OPTIMA FILE DEFINITION

10.3 STAMINA 2.0 PROGRAM

This program uses a maximum of four disk files: input data file (file TAPE 5), system output file (file TAPE 6 — generally the SYSOUT file), acoustic information file (file TAPE 8), and input/output time-share file (if subprograms FILEO and FILEC or their equivalent are used).

The input/output time-share file is used only to prompt the user to input names of the input data file and output acoustics file, if FILEO and FILEC are in use. This use of an interactive mode allows the user to open and close files at the time of execution of STAMINA 2.0.

The input data file (described in Section 2.2 of the User's Manual) must be created as a data/text file before the execution of STAMINA 2.0. Once the input data file has been created and saved as a permanent file on disk, STAMINA 2.0 will equivalence this input file to file TAPE 5 — using FILEO or an equivalent job control language (JCL). This input file is the "input batch stream" required to execute STAMINA 2.0. If the data contained on this file are incorrect or incomplete, the program will not execute successfully and will terminate abnormally; therefore, it will not successfully complete the output acoustic information needed for OPTIMA. The record size for the input file is 80 bytes, and the length of the file will depend on the system model used in STAMINA 2.0 (see Sec. 2.2 in User's Manual).

Output from the program is directed to a printed file that is equivalenced to file TAPE 6. This file is the standard output file (SYSOUT). Section 2.3 of the User's Manual describes the normal output printed to this file by STAMINA 2.0. It contains an echo, in report format, of all input data received from file TAPE 5 and, upon successful completion of the program, a final table of acoustic information as a function of receivers in the model. This file will also be the file to which all error or warning messages are printed.

As noted in the User's Manual, the main difference between the STAMINA 1.0 and 2.0 programs is that STAMINA 2.0 will generate, in a single run, acoustic information for each receiver — as a function of barrier height perturbation. Therefore, an additional output file (the "acoustics file") is written to file TAPE 8 and must be saved upon completion of the STAMINA 2.0 run.

If the subprogram FILEC is used, it is possible for the user to save the acoustics file during program execution. If not, the supplied JCL must contain the information necessary for saving the file. This saved file will be used by OPTIMA, where it is referred to as file TAPE 24. The record length of the acoustics file is 96 bytes, and the length depends on the number of barriers, the corresponding barrier sections, the number of barrier height perturbations, and the number of receivers in the model. (See Sec. 2.4 of the User's Manual.)

Stamina 2.0 requires approximately 256 k bytes of memory to load and execute. The actual memory size depends on the machine used and the sizes of the arrays finally used in compilation of the program.

10.4 OPTIMA PROGRAM

OPTIMA is an interactive program using three files: a time-sharing input/output file, the acoustics input file, and a report format output file. Again, please note that the execution of OPTIMA assumes that STAMINA 2.0 has run successfully and that an acoustics file has been generated and saved on a permanent disk file.

The input/output time sharing file is used to prompt the user for the file names (if open and close options are allowed on user's system. See subprogram FILES description in Program Maintenance Manual Sec. 7.) The program will also ask the user if he wishes to have the standard output to be issued to the terminal as well as the output file. If the user desires, information similar to the output file will be written to the terminal. The program will equivalence file TAPE 5 to the user's terminal; therefore, the JCL must be written to equivalence the time share with tape unit 5. The maximum record size required for input/output or file TAPE 5 is 80 bytes.

STAMINA 2.0 generates the acoustics file as TAPE 8, which is used by OPTIMA as file TAPE 24. This file contains almost all the data OPTIMA needs. The information in this file is self-sufficient. OPTIMA can retrieve the appropriate barrier and receiver data without user interaction. The only information the user needs to supply during execution is the permanent file name (if open and close options are used). If open and close options are not used, the JCL must declare file TAPE 24 equivalent to the acoustics file. The record size of 96 bytes is the same as declared by STAMINA 2.0.

A record of formal headings and output from computations is made to a report file named TAPE 20. This file contains information similar to that issued to file TAPE 5 (input/output to the time-share terminal) if the user requested it. Generally, if the user selects many different barrier height perturbations in his study, a complete record of the results would be maintained on file TAPE 20. If the system allows opening and closing files during the OPTIMA run, the user would define a file name for the system to permanently save the file. (See Program Maintenance Manual Sec. 7, subprogram TERMAL, for comments concerning the closing of file TAPE 20.) Upon completion of the OPTIMA run, the output report file TAPE 20 can be copied to a printer to produce a hard copy of the run. (See Sec. 3 in the User's Manual for output form.) The record size is 80 bytes, and length will depend on the user's selections (number of) of barrier configurations.

OPTIMA requires approximately 256 k bytes of memory to load and execute. The actual memory size will depend on the machine used and the final array sizes used in the program.

11. INSTALLATION PROCEDURES

11.1 INTRODUCTION

This section contains the instructions on how to install and test the BCR programs written by:

Bolt Beranek and Newman, Inc.
50 Moulton Street
Cambridge, Massachusetts 02238

The programs were written for the Federal Highway Administration (FHWA) under contract No. DTFH61-80-C-00035 for the purpose of allowing a highway engineer to efficiently and effectively study various noise barrier designs, their cost, and their effectiveness.

Any installation problems should be directed to:

Mr. John S. Higgins, Project Manager
Federal Highway Administration
Demonstration Projects Division
1000 North Glebe Road
Arlington, Virginia 22201
703-557-9080

11.2 BCR PACKAGE CONTENTS

Included in this package are the following items:

A. A BCR User's Manual.

B. A BCR program tape.

C. A listing of all data sets on the BCR program tape.

D. A BCR program maintenance manual.

11.3 BCR TAPE CONTENTS

Tape File Number	Data Set Name
1	FHWA.STAMINA
2	FHWA.OPTIMA
3	FHWA.LOADJCL

Tape File Number	Data Set Name
4	FHWA.STAMRUN
5	FHWA.EXAMPLE1
6	FHWA.EXAMPLE2
7	FHWA.CLIST

1. FHWA.STAMINA - The revised STAMINA 2.0 source code.
2. FHWA.OPTIMA - The source code for the interactive OPTIMA program.
3. FHWA.LOADJCL - The IBM JCL used to create load modules for STAMINA and OPTIMA.
4. FHWA.STAMRUN - The IBM JCL and data necessary to run a sample STAMINA problem. (Free field data shown in Figures 21 and 22 of BCR User's Manual.)
5. FHWA.EXAMPLE1 - Noise Wall Data for STAMINA, shown in Figures 36 and 37 of the BCR User's Manual.
6. FHWA.EXAMPLE2 - Structure Barrier Data shown in Figures 58 and 59 of the BCR User's Manual.
7. FHWA.CLIST - TSO command list to Execute OPTIMA.

The BCR Program tape is a standard labeled 9 track tape written in EBCDIC at at 1600 BPI. The tape contains 7 sequential data sets, all with record lengths of 80 and block sizes of 800.

11.4 INSTALLATION PROCEDURES

A. Unload the BCR program tape using the JCL provided in Figure 11-1.

B. Create STAMINA and OPTIMA load modules using the IBM JCL stored in the data set FHWA.LOADJCL. (Since STAMINA and OPTIMA use a free formatted read, you must use a FORTRAN compiler that accepts free formatted reads (G1 or H extended)).

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```
//STEP1 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN     DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.STAMINA,
//     UNIT=2400-4,LABEL=(1,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.STAMINA,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//STEP2 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN     DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.OPTIMA,
//     UNIT=2400-4,LABEL=(2,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.OPTIMA,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//STEP3 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN     DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.LOADJCL,
//     UNIT=2400-4,LABEL=(3,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.LOADJCL,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//STEP4 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN     DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.STAMRUN,
//     UNIT=2400-4,LABEL=(4,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.STAMRUN,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//STEP5 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN     DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.EXAMPLE1,
//     UNIT=2400-4,LABEL=(5,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.EXAMPLE1,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//STEP6 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN  .  DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.EXAMPLE2,
//     UNIT=2400-4,LABEL=(6,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.EXAMPLE2,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//STEP7 EXEC PGM=IEBGENER,REGION=100K
//SYSPRINT DD SYSOUT=A
//SYSIN     DD DUMMY
//SYSUT1    DD DISP=(OLD,KEEP),VOL=SER=R15XX9,DSN=FHWA.CLIST,
//     UNIT=2400-4,LABEL=(7,SL,EXPDT=98000),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//SYSUT2  DD  UNIT=SYSDA,DISP=(,KEEP),DSN=LY.LYDPXX15.BCR.CLIST,
//    VOL=SER=LY0001,SPACE=(TRK,(10,5),RLSE),
//     DCB=(RECFM=FB,LRECL=80,BLKSIZE=800)
//
```

FIGURE 11-1: JCL TO UNLOAD TAPE

C. Run the sample STAMINA IBM JCL and data stored in data set FHWA.STAMRUN. Compare the STAMINA report with the report shown in FIGURE 23 of the BCR User's Manual. Since this example has no noise barriers, an empty FT08F001 OPTIMA data set will be created.

D. Run the other two data files (FHWA.EXAMPLE1, and FHWA.EXAMPLE2) through STAMINA and compare the results with the BCR User's Manual Figures 38 and 60, respectively. You must change the data set name on the FT08F001 JCL card on each run.

E. Execute the OPTIMA Command List as shown in Section 11.5. This Command List is set up to use the FT08F001 Output Data set from the FHWA.EXAMPLE1 STAMINA Run. It can be altered to use various STAMINA output FT08F001 Data sets. Compare the results with those in Section 11.5. (From FHWA. EXAMPLE1 File.) The OPTIMA output report is stored in FT20F001 and can be listed out rather than deleted.

F. If problems occur, fill in the BCR correction form shown in Section 11.6 and return to FHWA at address shown or call.

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11. 5 OPTIMA RUN (USING STAMINA OUTPUT FROM FHWA.EXAMPLE1.)

```
     EXEC 'LY.LYDPXX15.BCR.CLIST'

                    P R O G R A M   O P T I M A
                    ****************************

               BARRIER OPTIMIZATION PROGRAM USING
               PARTIAL SOUND ENERGIES COMPUTED BY THE
               STAMINA/BCR PROGRAM
                    BBN VERSION 1 -- 03/01/82

        PROBLEM TITLE
        *************

   NORTH FREEWAY


        RECEIVER AND BARRIER IDENTIFIERS
        AS OBTAINED FROM BCR INPUT FILE
        ************************************

   RECEIVER IDENTIFIERS  (NUMBER IN SYSTEM =    1)

  R1

   BARRIER IDENTIFIERS  (NUMBER IN SYSTEM =    1)

  B1


       BARRIER TYPE SELECTION
       **********************

            THE FOLLOWING CODES ARE USED TO DESIGNATE MATERIAL TYPES
            (CONSTRUCTION COSTS -- DATE : 1980)

             1 BERM      2 MASONRY  3 WOOD     4 CONCRETE 5 STEEL

   ENTER TYPE NUMBER (1-5) FOR EACH BARRIER ELEMENT. (LIST DIRECTED)
 ?
 3


      RECEIVER SPECIFICATIONS
      ***********************

      NUMBER OF PEOPLE REPRESENTED AND EXTERIOR
      DESIGN NOISE LEVEL FOR EACH RECEIVER

  ENTER NUMBER OF PEOPLE PER RECEIVER (0-1000). (LIST DIRECTED)
 ?
 1

  ENTER DESIGN NOISE LEVEL PER RECEIVER (40<). (LIST DIRECTED)
 ?
 67
```

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```
NORTH FREEWAY


     SUMMARY OF BARRIER AND RECEIVER DATA
     ************************************

 BARR ELE      ID          TYPE
        1      B1          WOOD

  REC NO.      REC ID        PEOPLE        DNL
        1      R1                1.        67.


                 EFFECTIVENESS/COST RATIO AND BARRIER HEIGHT MATRICES
                 ****************************************************

BARRIER SECTION          EFFECTIVENESS/COST                    CORRESPONDING
  NO  IDENT                    RATIO                      BARRIER HEIGHTS(IN FT)

 HEIGHT INDEX   1   2    3    4    5    6    7    8    1 2  3  4  5  6  7  8


    1  B1       *  17.  18.  18.  17.  14.  11.  10.   * 6. 8.10.12.14.16.18.

 HEIGHT INDEX   1   2    3    4    5    6    7    8    1 2  3  4  5  6  7  8


    BARRIER HEIGHT SELECTION FOR NOISE LEVEL AND COST CALCULATION
    *************************************************************

  ENTER THIS CALCULATIONS DESCRIPTION FOR OUTPUT FILE (80 CHARS)
 ?
MANUAL EXAMPLE W/ 1 BARRIER AND 1 RECEIVER

  ENTER BARRIER HEIGHT INDEX FOR EACH
  BARRIER SECTION.  (LIST DIRECTED)
?
8


NORTH FREEWAY

MANUAL EXAMPLE W/ 1 BARRIER AND 1 RECEIVER


 BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
   8
 CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
 18.


     R E S U L T S
     *************

REC     REC ID        LEQ      LEQ(Z(O))
  1     R1            62.0      71.0


BARRIER TYPE         COST
BERM                   0.
MASONRY                0.
WOOD              292600.
CONCRETE               0.
STEEL                  0.
****************************

 BARRIER COST = $   292600.
```

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```
   DO YOU WANT TO SELECT ANOTHER PATH OF HEIGHT INDICES
  ? (Y OR N)
 Y

   DO YOU WANT TO VIEW THE E/C MATRIX AGAIN
  ? (Y OR N)
 Y


                 EFFECTIVENESS/COST RATIO AND BARRIER HEIGHT MATRICES
                 ****************************************************

 BARRIER SECTION       EFFECTIVENESS/COST                  CORRESPONDING
   NO  IDENT                 RATIO                       BARRIER HEIGHTS(IN FT)

  HEIGHT INDEX   1   2    3    4    5    6    7    8    1 2  3  4  5  6  7  8

     1  B1       *  17.  18.  18.  17.  14.  11.  10.   * 6.  8.10.12.14.16.18.
  HEIGHT INDEX   1   2    3    4    5    6    7    8    1 2  3  4  5  6  7  8

      BARRIER HEIGHT SELECTION FOR NOISE LEVEL AND COST CALCULATION
      *************************************************************

   ENTER THIS CALCULATIONS DESCRIPTION FOR OUTPUT FILE (80 CHARS)
  ?
 MANUAL EXAMPLE W/ 8 FT BARRIER

   ENTER BARRIER HEIGHT INDEX FOR EACH
   BARRIER SECTION.  (LIST DIRECTED)
 ?
 3




 NORTH FREEWAY

 MANUAL EXAMPLE W/ 8 FT BARRIER


  BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
    3
  CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
   8.


     R E S U L T S
     *************

 REC    REC ID         LEQ      LEQ(Z(O))
   1    R1             69.1      71.0

 BARRIER TYPE          COST
 BERM                       0.
 MASONRY                    0.
 WOOD                   91960.
 CONCRETE                   0.
 STEEL                      0.
****************************

  BARRIER COST = $    91960.
```

BEST DOCUMENT AVAILABLE

```
   DO YOU WANT TO SELECT ANOTHER PATH OF HEIGHT INDICES
  ? (Y OR N)
 Y

   DO YOU WANT TO VIEW THE E/C MATRIX AGAIN
  ? (Y OR N)
 N


      BARRIER HEIGHT SELECTION FOR NOISE LEVEL AND COST CALCULATION
      *************************************************************

   ENTER THIS CALCULATIONS DESCRIPTION FOR OUTPUT FILE (80 CHARS)
  ?
MANUAL EXAMPLE W/ 12 FT BARRIER

  ENTER BARRIER HEIGHT INDEX FOR EACH
  BARRIER SECTION.  (LIST DIRECTED)
?
5



  NORTH FREEWAY

  MANUAL EXAMPLE W/ 12 FT BARRIER


   BARRIER HEIGHT INDEX FOR EACH BARRIER SECTION
     5
   CORRESPONDING BARRIER HEIGHTS FOR EACH SECTION
   12.


       R E S U L T S
       *************

  REC     REC ID        LEQ      LEQ(Z(O))
    1     R1            66.4       71.0


  BARRIER TYPE          COST
  BERM                     0.
  MASONRY                  0.
  WOOD                150760.
  CONCRETE                 0.
  STEEL                    0.
***************************

   BARRIER COST = $   150760.

   DO YOU WANT TO SELECT ANOTHER PATH OF HEIGHT INDICES
  ? (Y OR N)
 N

  END OF ALL CASES
```

BCR CORRECTION FORM

Mr. John Higgins, Project Manager
Federal Highway Administration
Demonstration Projects Division
1000 North Glebe Road
Arlington, Virginia 22201

(703) 557-9080

SUBMITTED BY: ____________________

BCR Problem:

***PLEASE FURNISH A LISTING OF THE INPUT DATA, OUTPUT REPORT, AND ANY SOURCE CODE CORRECTION THAT SOLVED THE PROBLEM.

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